Analysis and Testing of Textiles)

(From Fibre to Fabric)

BY

SHANKAR D. VASHIST

B. Sc. (Hons); M. Sc (Allahabad); M.Sc. (Tech) Manchester.
A I. C. (London); M. Tex. Inst. (Eng.)

Formerly Govt. of India (U. P.) technical Scholar
(Textiles) in England; Sometimes attached
to Messrs Platt's Bros. Spinning and
Weaving Machinists, Oldham and
India Stores Deptt., London.
Late Dyer, Bleacher and Finisher Khatau Mekanji
Mills Bombay; Textile Expert, Gaekwar Mills
Billimora and Technical Editor
'The Textile Industry', Ahmedabad,
Etc.

WITH A FOREWORD

BY

R. K. MISRA

General Manager—Delhi Cloth and General Mills, Delhi.
Late superintendent The Hormusjee Commissariat
Group of Mills, Bombay ; Weaving master
and Manager, The Morarjee Gokul Dass
Mills and Khatau Mekanjee Mills,
Bombay. Etc. Etc.

1938

TO

MY BELOVED PARENTS

The Author

PREFACE

A MONG the many industrial problems which have been engaging the attention of the Industrialists, Economists, and the Government, the Textile Industry is one which stands second to none.

In recent years this Industry has reached a high stage of perfection and though much has not been accomplished in the way of improving the technique in this country, great progress has undoubtedly been made in this direction in countries like England, United States of America, Germany and Japan.

Though not unaware of the difficulties which are bound to be encountered with, in producing a book relating to an industry which has reached such a high standard of perfection, I have endeavoured to offer in the following few pages some of the results of my experiences, relating to testing of textile materials, gained in England, the continent and in this country during my several years connections with various Textile Associations and the manufacturing concerns. In presenting this book, I hope that it will afford, not only to those engaged in the Industry, a concise and intelligible description of the chief operations involved in the testing of raw materials, yarns, woven and knitted fabrics, and bleached, dyed and finished products but also to the men engaged in the commercial side of the Textile trade, the Research technologist, and to the student a knowledge which would be found useful and necessary to possess.

In the end, I wish to acknowledge my indebtedness to Khan Bahadur A. G. Khan, B. A. (Alig), M. Sc. (Delhi), M. Sc. (Tech) Manc. M. I. E. E. (Lond), A. M. I. Mech. E (Lond), M. I. E. (India), Deputy Director of Inspection, Indian Stores Department, New Delhi, who among his many important duties found time to go through the manuscript and for making various valuable suggestions, thus enhancing the value of this work.

28th Jan. 1938
VASHIST ASHRAM   }   S. D. VASHIST
LUCKNOW (India)

FOREWORD

IN presenting this book, the writer has done his best to put before its readers the results of his experiences both in India and abroad in the domain of Textile manufacture. Every attempt has been made by the author to deal exhaustively with all the aspects of Textile Testing from fibre to fabric.

Such a publication as this, will, I believe, act not only as a technical guide to those entrusted with the purchase and inspection of Textile materials but will also prove useful to manufacturers and all those engaged in the Textile Industry.

Mr. S. D. Vashist, who is particularly qualified for the task he has set himself, has devoted considerable time and labour towards the preparation of this volume, and I am sure it will be found useful by the students especially interested in the testing of Textile fabrics, etc.

R. K. MISRA,
General Manager,
The Delhi Cloth Mills,
DELHI

CONTENTS

CHAPTER I.—*Textile Fibres*

Section I—Cotton Fibre

Cultivation and Characteristics; Development of Cotton hairs; Staples; Physical properties of cotton Fibre. The Chemical properties of cotton.

Section II.—Bast Fibres

(*a*) *Flax.*—Cultivation and Characteristics; Physical and Chemical properties of Flax; Structure of Flax Fibre. Geographical Distribution; Manipulation in the raw state. Retting.—(1) Immersion the straw in a river or stream (2)—Steeping in cold water in pits (3)—Soaking in warm water (4)—Spreading over grass.

(*b*) *Jute & Hemp.*—Geographical Distribution; Cultivation and Characteristics; Physical and Chemical properties.

(*c*) *Ramie & China Grass.*—Characteristics and general properties of Ramie and China grass. Structure of the Fibre. Physical and Chemical properties.

Section III.—Wool

Definition of wool and hair; Distribution and characteristics of various qualities of wool; Sorting; Fibre diameter of wool; Physical properties of wool; Chemical constitution and properties.

Section IV.—Silk

Spinning of cocoon ; Characteristics of natural silk ; Structure of Silk ; Diameter of Cultivated silk ; Physical and chemical properties ; Cocoon reeling.

Section V.—Rayon or Artificial Silk

What is artificial silk ? Various types of Rayon.

Their manufacture. *(a)* Cellulose Nitrate process. *(b)* Cuprammonium process. *(c)* The Viscose process. *(d)* Acetate process.

Fundamental principles in the production of Rayon ; Physical Properties of Rayon such as lustre, size of filaments, extensibility, hygroscopicity, and tenacity ; Chemical properties of Rayon.

CHAPTER II.—Examination of Textile Fibres

Section I.—Chemical Examination of Textile Fibres

Classification of Textile fibres ; Chemical examination and detection of cotton, Wool, Jute, Hemp, Ramie, China Grass, Silk and Artificial silks. Burning tests of Textile fibres.

Section (2)—Microscopic & Micro-Chemical Examination of Textile Fibres

Microscope :—its parts and manipulation and testing ; Preparing sections for testing purposes.

The microscopical and micro-chemical examination of cotton, (Indian, Egyptian, American and Sea Island) Flax, Jute, Hemp, Wool and Hair, Silk and Rayon (Artificial silk).

(*a*) Micro-Chemical tests for Flax, Jute and Hemp.

(*b*) Micro-Chemical tests for Cotton and linen.

(*c*) Micro-Chemical tests for wool, cotton and silk.

(*d*) Micro-Chemical tests for artificial silk and cotton.

CHAPTER III.—*Yarn Testing*

Section I.—*General Examination, including the strength and twists per inch*

Testing for quality and evenness; Elasticity, Breaking Strength; Twists per inch; Colour, Counts and Percentage of moisture; Various types of machines used in testing—Their complete details, manipulation and use.

Section II.—*Yarn Counting System*

Definition of hanks and counts, cotton counts; worsted counts; woollen counts; Woollen yarn Systems in general use :—(*a*) Yorkshire skeins (*b*) Galashiels System (*c*) West of England Counts (*d*) The Hawick System (*e*) Alloa Yarns System (*f*) Leicester Lambwool System (*g*) Deewbury Counts (*h*) Rochdale woollens (*i*) American System (*j*) Run System (*k*) American cut System; Bump Cotton Yarn Counts; Linen Counts; Fixed length System; The Silk denier System; Jute Counts; Raw Silk Yarn Counts; Twists in Yarn; Method of Counting resultant Counts.

Section III.—*Count Estimation & Conditioning of Yarn*

Estimation of Counts where long lengths are obtainable; Estimation of counts where only short lengths of thread is obtainable; Conditioning of yarns; Method of test for moisture; Standard of regains for various textile fibres.

CHAPTER IV :—*Testing of Woven & Knitted Fabrics*

Section I.— Examination of Woven Fabric—

Weight of cloth per unit area ; Determination of reeds and picks per inch ; Pick glass and its use ; Method of dissecting the cloth for weave ; Width and length of cloth ; Shrinkage tests of warp & weft ; Shrinkage of Finished fabrics ; Wearing tests ; Common faults in cloth ; Stains in woven fabrics ; Mildew Stains.

Section II.—Analysis and Testing of Knitted Fabrics

Character of the stitch employed ; kind of yarn used, its count and direction etc. Type of machine used for knitting a particular type of fabric ; Machine gauge ; Finishing processes ; Particulars of design.

Section III.—Strength Tests of Fabrics—

(*a*) Bursting tests (*b*) Breaking tests. Various types of testing machines used in the determination of Tensile strength of woven fabrics—Their complete details, manipulation and use.

CHAPTER V.—*Determination of Dressings and Finishing Materials in Textile Fabrics*

Dressing of yarn for the loom.

Adhesive substances :—Wheat Flour, Rice flour ; Topioca flour ; Soluble starches ; Dextrine ; Gloy ; Gum-Tragasol.

Emollients or Softeners :—Tallow ; Castor oil ; other Fatty Oils ; Glycerine ; Mineral oils & Paraffin ; Wax ; Soaps ; Patent softeners.

Deliquescents :—Zinc Chloride ; Magnesium Chloride ; Calcium Chloride ; Glycerine.

Weight-giving Substances:—China clay; Epson Salt—Barium Sulphate; French Chalk.

Anti-septics :—Inorganic and organic substances.

Tests for Gluten & Starch in flours ; Qualitative and quantitative tests for Gluten ; Test for colours of flours ; Test for consistency of flours ; Test for starches ; Size estimation in cotton aud linen fabrics ; Estimation of moisture in finished fabrics ; Estimation of fatty and waxy matter in textiles.

Estimation of mineral matter, such as china clay, magnesium, calcium, zinc, and other inorganic chemicals.

CHAPTER VI.—*Testing of Bleached and Coloured Fabrics*

Section (1)—Testing of Bleached Fabrics

Mechanical and Chemical defects associated with the bleached fabrics ; Tenderness ; Qualitative and Quantitative determination of tenderness by :—

(*a*) Methylene Blue test (*b*) Fluidity measurement (*c*) Copper number determination. (Schwalbe Method. Hagglind Method. Hey's Micro-method.)

Section (2) Testing of Dyed Fabrics

Fastness to domestic washing ; Fastness to water ; Fastness to boiling and alkalies ; Fastness to acids ; Fastness to ironing and steaming ; Fastness to friction and rubbing ; Fastness to street dirt and mud ; Fastness to perspiration ; Fastness to bleaching ; Fastness to Sunlight. Action of light on coloured fabrics. Fastness of Vat Dyestuffs ; Fastness of Mineral Khaqi Colours. Identification of dyestuffs used for dying Textile materials.

CHAPTER VII—*Defects in Textile Goods, their causes, prevention and removal*

(1) Defects in yarns ; defects due to the raw materials; Defects due to inefficient manipulation and settings of the spinning machinery ; Defects due to subsequent operations.

(2) Defects in cloth:—Defects in material ; faulty preparations and bad manipulation and settings during the actual weaving operation on looms. Dobbies ; and Jacquards.

(3) Defects in knitted fabrics ; Defect in yarns machine settings, careless handling of materials ; and those defects introduced in the finishing processes.

(4) Defects in Rayon (artificial silk).

CHAPTER VIII.—*Inspection of Textile Materials*

Section 1—Preparation of a Specification

Importance of Specifying :—The counts, sizing and loading materials ; Width and weight of cloth ; Ends and picks per inch ; Breaking strength ; Type of testing machine used and Size of test specimen ; Shrinkage tests ; Fastness of dye tests ; Water tightness tests and Tests for Ropes and cordage. Visual Examination of Textile materials.

Section II—Outlines of some specifications

Specifications Nos. 1—8, for Cotton Twine 5/10^s , Lining cloths (Cotton Satin), Muslin Bleached, Water proof Cotton Canvas Sheets, Serges Blue worsted, Broad cloth woollen, Cloth Gunny Jute and Canvas Flax.

LIST OF ILLUSTRATIONS

(15)

CHAPTER I

TEXTILE FIBRES

SECTION I—Cotton.

SECTION II—Bast Fibres.

        (*a*) Flax and Linen.

        (*b*) Jute.

        (*c*) Hemp.

        (*d*) China grass and Ramie.

SECTION III—Wool.

SECTION IV—Silk.

SECTION V—Rayon or Artificial Silk.

SECTION I

Cotton Fibre

COTTON, the seed hairs of a plant, genus Gossypium, possesses special natural characteristics which greatly facilitate its being twisted or spun into a thread. It can be cultivated within the latitudes of $40°N$ and $30°S$ and is grown in many countries, the principal being the United States of America, where it is grown principally in the States lying to the south-east; the largest production of good average staple and grade is grown in Texas. The cotton grown in India and in China is very low in staple and in grade and is only suitable for spinning very low counts. The cotton grown in the British Dominions by the British Cotton Growing Association is improving in staple and in quality year by year. The cotton used for spinning the finer counts is grown in Egypt where much time and thought is now being given to the cultivation of cotton.

Naturally, the cotton fibre produced from any plant and from any country is dependent on the kind of soil in which it grows, the method of cultivation and its freedom from insect damage. It is generally agreed that

the best soil for the cultivation of cotton is one composed of loam with alkaline "neutro-saline matter and calcareous and magnesium bases," and to get best results considerable rainfall is required until the fruit season is due. In the growing of cotton the farmer has to use his land carefully, see that it is well worked and fertilised. But he is handicapped in his work by the ravages of various pests, the principal of which is the "boll-weevil." Careless cultivation results in loss in weight and in quality; only the best of attention will secure a fibre of ideal qualities for the spinner which is one as uniform as possible in quality, in length, in diameter and in hair weight. When cotton is taken from the plant, the seeds are also gathered and these have to be separated before the cotton can be graded. By "grade" is meant its appearance as regards cleanliness, freedom from leaf, sand, moisture and other impurities. By staple is meant "the average length of the bulk of the fibres" and it requires much practice and great care before one can judge cotton even fairly well.

THE DEVELOPMENT OF COTTON HAIRS

It has been indicated above that the cotton hair is derived from the plant known to botanists as Gossypium. Numerous species of the plant bear cotton hairs but the chief producers of the cotton of commerce are Gossypium arboreum (tree cotton); G. herbaceum (Indian-varieties); G. barbadense (long-stapled cotton including Sea Islands and Egyptian); and G. hirsutum (American or Uplands cotton). The flower buds come at the end of the flowering branches and the branch lengthens by the growth of a bud which arises in the junction of the leaf

which preceded the flower bud. The flower bud has a three-cornered cover of bracts and the flower proper begins to develop just 23 days before the flower opens. During the 24th day the petals fade and the ovules become fertilised. Around each ovule two seed coats are formed, completely jacketting the seed save for a minute pore at the top, through which the fertilisation takes place. From the outer epidermis of the outer seed coat the seed-hairs arise. These seed coats become thickened and horny forming thereby a protective covering for the embryo plant. The hairs are formed by the extension outwards of the walls of certain of the epidermal cells of the outer seed coat. These sproutings begin on the day of flowering. Full hair diameter is attained almost at once and elongation goes on at the rate of about 1 milli-metre a day until in about 24 days full length (about 2,000 times the diameter) is achieved. Up to this point the hairs are thin-walled but on the 21st day of sprouting secondary deposits of cellulose begin and the hair wall thickens. A well-thickened wall is about 0.004 mm. thick (1/6000 inch). The hairs now consist of the outer cuticle, primary cellulose wall, secondary cellulose wall and central canal or lumen. The oft referred-to convolutions of the cotton hair are said to be due to the withdrawal of the living contents (protoplasmal) of the central canal at the time when the boll bursts and the hairs come under the full influence of the sun.

THE PHYSICAL PROPERTIES OF COTTON

Cotton hairs vary in length in several ways. The hairs on any one seed will be of different length ; hairs from one type of plant constantly vary from those of

another type and influences of soil, climate, crossing, etc., are regarded as having definite effect on hair length. This variation in length is important when one considers that 1/8 inch is of real significance to the spinner.

Mathews gives a table of hair lengths, collated as a mean of several observers, as below :—

NAME OF COTTON				LENGTH IN M.M.
Sea Island (Florida)	...	...	...	45·7
Fgyptian (Gallini)	...	...	...	37·2
Brazilian (Maranham)	...	...	...	28·8
Peruvain (Rough)	...	...	...	29·9
West Indian	...	...	...	32·3
Chinese	...	...	...	21·4
American (Upland)	...	...	...	29·5
American (Mississippi)	...	...	...	24·2
African	...	...	...	27·6
Indian (Hingunghat)	...	...	...	28·3
Indian (Scinde)	...	...	...	20·4

These figures are, of course, averages for the measurements of many hairs, but it should be mentioned that it is impossible to get cotton of even a reasonably uniform length of staple. Uniformity of length alone would not give the best results in spinning but considerable importance attaches to the diameter of the fibre. While this is a difficult factor to measure, many attempts have been made to do so and much patient work has been done. Mathews has collated the means of several

observers and his figures (for the same growths of cotton as above) are given as follows :—

NAME ON COTTON			DIAM. IN MICRONS
Sea Island (Florida)	...	... ...	16·18
Egyptian (Gallini)	...	... ...	17·1
Brazilian (Maranham)	...	... ...	20·4
Peruvian (rough)	...	... ...	21·5
Chinese	...	... ...	24·1
American (Upland)	...	... ...	19·4
American (Mississippi)		... ...	13·4
African	...	... ...	20·8
Indian (Hingunghat)	...	... ...	20·0
Indian (Scinde)	...	... ...	21·3

Cotton hairs are not of uniform diameter throughout their length, but taper towards the end most remote from the seed. This "tail" which is quite marked in certain varieties has usually no lumen and no convolutions. The Shirley institute Manchester has adopted a method of diameter measurement which overcomes the difficulty of microscopic measurement due to the convolutions. The cotton is immersed in 18 per cent. caustic soda solution, the convolutions disappear, and the hair becomes an almost regular cylinder directly related to the diameter of the fully grown hair in the boll before bursting. The hairs are washed and dried and the "mercerised diameter" of the sample thus measured bears approximately the same ratio to the diameter of the unmercerised hair for all varieties of cotton.

Considerations of strength may be made under the heads of "hair strength," "grades strength," and "yarn strength." The "graders strength" is unconnected with

"hair strength" and is really an impact strength test applied to tufts of hairs equalised as far as possible.

In making such measurement an exact definition of a quantity must specify the conditions under which it is to be measured and give standard corrections to be made when these conditions vary. No neglect of influences such as humidity, temperature, and tension should be made. O'Neil has recorded the following figures for tensile strength of single cotton hairs :—

Description of cotton.	Mean Breaking strain in grams	Description of cotton.	Mean Breaking strain in Grams.
Sea Island ...	83·9	Orleans ...	147·7
Benguela ...	100·6	Pernambuco ...	140·2
Upland ...	104·5	Dhallerah ...	141·9
Brazil (Maranham)	107·1	Comptah ...	163·7
Egyptian ...	127·2	Queensland ...	147·6

Pearce gives the following interesting physical factors for individual fibres :—

Variety	Length cms.	Rigidity Dynes sq. cm.	Weight 10 grms
Sea Island	4·2—4·5	0·010—0·021	5·9—6·7
Egyptian (Nubarri)	3·6	0·024	6·3
Egyptain (Affifi)	3·1	0 032	5·6
Peruvian (Hybrid)	2 9	0·063	7·7
Trinidad (Native)	2·6	0·045	4·9
American (Memphis)	2·6	0·039	5·3
American (F. G. M.)	2·4	0·061	5·6
Pernams	2·2	0·071	6·7
Indian Bharat	1·7	0·111	5·8

THE CHEMICAL PROPERTIES OF COTTON

Freed from mechanical impurities such as leaf, stalk, sand, etc. commercial cotton has been analysed by many workers and the following may be regarded as a reliable analysis:—

Analysis of cotton Fibre : U. S. Department of Agriculture. Bull. No. 33—

Cellulose	...	...	83·71%
Protein	...	...	1·50%
Fat	...	...	0·61%
Water	...	...	6·74%
Nitrogen-free extract	...	...	5·79%
Ash	...	...	1·65%

Action of Heat on cotton—cotton withstands heat to fairly high temperatures without decomposition or alteration. At 160°C, dehydration of the cellulose occurs and at 250°C. it turns brown indicating that carbonisation has commenced.

Action of Light.—It is well-known that when cotton fabrics are long exposed to light, especially direct sun light, gradual deterioration occurs. It is, no doubt, the violet and ultra-violet rays that are destructive.

Action of Water.—Cotton is unaltered and insoluble in cold and in boiling water though Lester has recorded a loss of 2 per cent of weight on repeated boiling. When cotton is subjected to the action of steam under high pressure it undergoes disintegration and turns yellow.

Action of Cuprammonium Solution.—Cotton dissolves in Schweitzer's reagent but only slowly unless certain steps to accelerate the action are taken. First treat the cotton with strong caustic soda until the hairs

swell; squeeze out excess liquid and wash with strong ammonia; then treat with Schweitzer's reagent and the cotton quickly dissolves. The value of this reaction commercially lies in the manufacture of Rayons.

Action of Acids.—Organic acids have very little action on cotton except in specific cases. Tannic acid, for example, is readily absorbed up to 7 to 10 per cent. of its weight from aqueous solution. The more important inorganic acids have little effect on cotton, but if the cotton is allowed to dry without washing out the acid, tendering occurs owing to the increased concentration of the acid on drying. Concentrated Sulphuric acid produces amyloid and this fact is taken advantage of in the preparation of Vegetable Parchment. Concentrated Nitric acid acting in conjunction with sulphuric acid, nitrates the cellulose and produces the series of compounds known as nitrocelluloses or pyroxylins. From these substances guncotton, collodion, celluloid, and the nitro-variety of rayon are produced. Dry Hydrochloric acid gas has no effect on cotton, but in the presence of moisture decomposition is rapid.

Action of Alkalis.—The action of concentrated alkalis (30 per cent.) is characteristic. The cotton hairs swell up and become cylindrical. Their tensile strength and their affinity for dyestuffs are increased. A compound known as alkali-cellulose is formed. The reaction is the basis of the mercerising process. Concentrated caustic soda in the presence of carbon bisulphide reduces cotton to a gelatinous mass soluble in water. This reaction forms the basis of the production of the viscose type of Rayon and is discussed in Section V of this chapter.

SECTION II
Bast Fibres

(a) FLAX

The common cultivated Flax (Linum usitatissimum) belongs to the botanical order Linaceæ, and is supposed to be a native of south-eastern Europe and western Asia. It has been cultivated since the dawn of history. Flax is an annual plant from 1 to 3 feet in height. The seed boll consists of 5 chambers and when full contains 10 seeds. The seeds germinate very quickly under favourable conditions of moisture and temperature and the plant as a whole benefits by frequent rains. The constitution of the soil has a marked effect upon the quality of the fibres and good crops can only be secured by attention to cultivation details such as weed-removal. Plant breeders have given considerable attention to the production of flax seed, suitable for given soils, resistent to disease, or productive beyond the average.

PROPERTIES OF FLAX (a) *Physical:*—The fibre of commerce—as distinct from the "ultimate fibres" of which the commercial fibre is composed—ranges in length from Egyptian which averages 40 inches to the

2

Silesian which is no more than 11 inches on the average as shown in the table below :—

Kind	Mean length of purified Flax Fibre mm.	Mean breadth mm.
Egyptian	960 (37·8 ins.)	0·255
Westphalian... ...	750 (20·5 „)	0·114
Belgian (Courtrai) ...	370 (15·2 „)	0·005
Austrian	410 (16·1 „)	0·202
Prussian	280 (11·0 „]	0·119

Good qualities of commercial fibres average 20 inches and should be free from short lengths. The ultimate fibres vary from $1\frac{1}{2}$ to 2 inches in length and from $\frac{1}{800}$ to $\frac{1}{1200}$ inches in diameter.

The colour of flax during its raw state is very variable and possesses a range of hues from a creamy tint in the best Belgian flax, through bluish brown to greenish-grey in the inferior qualities, a feature which is largely governed by the fermentative action which takes place during retting. The impurities of raw flax consist of numerous pectose substances, together with a percentage of soft tissues which may be adherent, the former being in the nature of resinous gums, and serve as cementing mediums surrounding the cell-elements and also intermixed somewhat with the adjacent tissues. It is hardly likely, however, that the pectose substance which binds the cell-elements is identical to that which is present in the adjacent tissues.

By treatment with dilute caustic soda solution, it is possible to separate the "ultimate fibres" in flax and

similar fibre-strands. In this state the ultimate fibres may be easily counted, and if a short pencil of material of known length and weight is examined, the weight per centimetre of the ultimate fibres can be determined. Ultimate fibres having the greatest weight per cm. are to be found in the root end of scutched and hackled flax, in root tow as opposed to top tow from the hackle, and in the shortest strands in a sliver. Spinning quality in ordinary flax does not appear to depend on the weight per cm. of the ultimate fibre, since this feature shows no significant variation throughout a range of materials extending from 12 leas (4 lb.) to 200 leas (66·6 lb.).

Flax fibres always twist in a clockwise direction when drying ; hemp and jute fibres twist in the reverse direction. Flax and hemp may therefore be readily distinguished from one another with the naked eye.

The drying of these fibres is therefore in all cases accompanied by a twisting up of the component fibrils. Conversely, moistening is accompanied by an untwisting of the fibrils. This tendency of fibres to twist may be expected to have an important bearing upon the properties of yarns.

Flax and cotton fibres show a great similarity in structure despite the fact that they are not homologous ; it is probable that the properties of cellulose play a large part in determining the architecture of vegetable fibres. Closely similar 'dislocation marks' occur in flax and cotton. The nature of the 'stomata' of de Mosenthal and 'slow spirals' of Balls is elucidated by a comparison of flax and cotton fibres. Both flax and cotton fibres have minute pores in the cell wall.

PROPERTIES OF FLAX (*b*) *Chemical*—Flax, when properly prepared is almost pure cellulose and is, almost unlignified. It will be understood, of course, that the composition varies slightly in different qualities, but the following table gives an average analysis.

Cellulose	...	...	76 %
Pectic matter	...	...	10·5%
Water	...	...	9 %
Fat and wax	···	...	3·5 %
Ash	...	···	1 %

Consequently, flax behaves towards reagents very much in the same way as cotton. Its structure has no doubt a definite effect in this connection and it takes up mordants and dyes less readily than cotton. The encrusting pectin substances which are difficult to remove make it harder to bleach. It does not withstand boiling alkaline solution, bleaching powder, solution, or other oxidising agents, so well as cotton. In ammoniacal copper oxide solution it swells up, but not in the globular way exhibited by cotton and does not pass into complete solution.

Geographical Distribution—Flax is grown in a large number of countries but those which export in any appreciable quantity are Russia, Latvia, Esthonia, Lithuania, Poland, Belgium and Holland. Other countries which occasionally export in small quantities are Ireland, France, Germany, Italy, Egypt, Kenya and Canada. The production of some of the above countries is as follows—

Russia. Prior to the war the export averaged 250,000, tons per annum, but no statistics are available as to the quantity now produced.

Latvia. 20,000 tons per annum, all water-retted (Motchenetz or white flax).

Esthonia. 9,000 tons per annum, all water-retted, and of good quality.

Lithuania. 12,000 tons per annum, both water-retted and dew-retted (Slanitz).

Ireland. During recent years the production averaged 7,000 tons per annum, and in 1927 it fell to 5,000 tons.

For some years past, the average yield per acre has been 23 stones of scutched flax. With the new seed—the J.W.S Pedigree Seed—yields of 40-50 stones per acre have been realised and exceptional cases show yields of 60 stones. The yield per acre is usually about 5 per cent. of the pulled straw. For example, if an acre of ground gives 100 cwts. of green straw, the fibre yield will be about 5 cwts. A great deal depends on the acre and labour expended on the field and the crop. A well cultivated field will give from 110-120 cwts. of green straw.

The average yield of fibre per acre in Belgium is about 6 cwts ; in Ireland 5 cwts; in Latvia and Esthonia 4 cwts ; and in Russia 3 to 4 cwts.

MANIPULATION IN THE RAW STATE :—Three months after the seed has been sown, the plant flowers and approximately one month later, during which the flowers turn to seed, the flax is ready for pulling. It is very seldom cut as this would entail a loss of about 6 inches in the length of the plant or straw. After pulling, the straw is built into stooks or sheaves and left to dry.

The seeds are then removed by drawing handfuls of the straw through a very coarse comb or "ripple," the operation being termed rippling. The seeds yield linseed oil and are made up into feeding for cattle. After this operation, the flax straw is ready for the next process, known as "retting". In some districts rippling and retting are carried out directly the flax is dry, but in others, some time is allowed to elapse before doing so.

Retting.—This is the most important process in the manipulation of the flax straw, prior to the extracting of the fibre. The principle underlying retting is to dissolve the gum which fastens the fibre to the woody core and the bark of the straw. The vegetable matter which surrounds the fibre is also dissolved, thus leaving the fibre loose and in a form suitable for extraction.

There are four principal methods of retting : (1) By immersing the straw in a river or stream. (2) By steeping in cold water in pits. (3) By soaking in warm water in tanks. (4) By spreading on grass. The first three methods are termed water-retting and the last one dew-retting. In the same order, the flaxes produced are known as white or "Motchenetz." and as brown or "Slanitz."

Retting in running water is extensively carried out in the River Lys, especially at Courtrai, in Belgium. The flax obtained here—known as white Courtrai—is generally accepted to be the best in the world. Briefly the operation of water-retting is as follows : The flax is made up into bundles known as "Bonjeaux" and packed into

open sparred crates. These crates are lined with straw and the flax is made to stand upright on its roots. The crates are then covered by planks and weighted with stones to sink them to the required depth. Each crate holds from 20 to 30 cwts. of flax. The same method is followed for steeping in pits and for steeping in warm water in tanks.

The method followed in dew-retting is to spread the flax lightly on grass and then leave it to the action of rain or dew.

In these methods, fermentation sets in after a few days and is completed in a period of eight to twelve days. A great deal depends on atmospheric conditions and because of this the successful retting of flax depends on the experience and knowledge of those responsible for this process. A few hours too little or too long in the water or on the grass make a great difference in the quality of the fibre. One might almost say that there is an exact moment for removing the flax, and that is, when the fibre will part freely and easily from the woody core and the bark.

Until recent years the only methods used were steeping in running water, steeping in pits and dew-retting, but simple though these methods are they have their disadvantages. For instance, steeping in running water can only be carried out in some places at certain times of the year because of damage done to fishing. At Courtrai, the period is from 15th April to 15th October. Dew-retting is seldom carried out during winter because of the snow.

In order to overcome these disadvantages various other methods have been tried. Harper mentions warm water-retting, hot water and high pressure steam-retting and various chemical agents. Of the above, warm water retting has probably been the most successful. One such method, known as the Legrand Van Steenkiste method, has been extensively adopted in France and Belgium. Oakley gives a full description of this method of water-retting and, comparing it with steeping in running water, it is claimed that it requires half the time, is independent of atmospheric conditions and can be carried on all the year round.

The flax produced by water-retting and dew-retting shows very different effects in subsequent processes and so should be kept separate. When boiled, dew-retted flax shows a dull grey colour, whereas water-retted flax is much lighter. Dew-retted flax must not be soured as it turns black. Again, they bleach at a different rate so that if mixed, the yarn and cloth will have a spotted appearance.

After retting has been completed, the straw is thoroughly dried by spreading it on short grass or by building it into stooks. The latter method is the one usually adopted though in some places it is now done in steam-heated chambers.

The next operation is the subjecting of the dried straw to the action of flutted rollers, the object being to break or split up the woody core and the bark. This is followed by "scutching"—the name given to the operation which consists of striking the stalks with a wooden knife, by which the adhering wood is separated

from the fibre. In Russia and other countries where each grower prepares his own production, this operation is usually performed by hand, by means of a wooden knife. Where large quantities are dealt with, however, the flax is sent to scutching mill. In the latter, a number of beaters are fixed to a horizontal shaft or shafts, which revolve at high speed. The flax is acted upon by the beaters, after which the whole length of the fibre should be perfectly clean.

(*b*) JUTE

The jute fibre is a product of the stem of several plants belonging to the genus Corchorus, and the natural order of Tilliacae. It is therefore a true bast fibre and is prepared in a somewhat similar manner to other fibres of this class. The good yield and the ease with which the fibre can be extracted from its cellular matrix, together with its economic importance, makes it the cheapest of all fibres found in commerce. Consequently its utility is reflected in the wide scope which it offers in the making of cheap materials in the nature of coarse bagging, sacks, wrappings, rugs and carpets, and as a backing or basic fabric for the preparation of oil cloth, etc.

True jute fibre is the product of Corchorus-capsularis or Jew's mallow, a plant which is indigenous throughout tropical Asia. There are many other fibres designated as jute which bear striking resemblances which are difficult to recognize by any other means than careful microscopical analysis.

The mature jute plant reaches a height of five or ten feet, while the raw fibre arrives in commerce from

3

four to seven feet in length, the colour varying somewhat due to the method which has been employed in retting, passing from a yellowish white in the best varieties to a yellowish brown or distinctly brown colour in the lower grades.

(c) HEMP

"HEMP" is a fibrous material obtained from the tissues of different species of plants. Some hemps such as common hemp (Cannabis-sativa), Sunn hemp (Crotolaria-juncea), Cuban hemp (Fourcroya-Cubensis), and Gambo hemp (Hibiscus-cannabinus) are directly obtained from the bast tissues of stems, while others such as New Zealand flax (phormum-tenax), sisal hemp (Agave-rigida), and Manilla hemp (Musa-textiles) are derived from the leaves. The species are widely separated, and so, there are structural differences which distinguish each fibre from its neighbour, with peculiarities adapting each for some particular purpose. In this class of Bast fibre, however, such differences are most difficult to detect though the general characters are fairly constant. Under natural conditions the shrub attains a height of six to fifteen feet. Whilst it is indigenous to India and Persia it is now cultivated throughout the temperate and tropical zones, including the United States. The raw fibre has many uses, being particularly adapted for the making of ropes, hawsers, carpets etc.. and is capable of being further utilized as a valuable substitute for the lower qualities of linen goods. Like flax it appears in commerce as strands ranging from 500 mm. to 1000 mm. in length, and varies in colour through grey, green, yellow and brown.

(d) RAMIE AND CHINA-GRASS

Although the terms ramie and China-grass are often used indiscriminately the fibres are not truly identical, the reason being that ramie, also referred to as "Rhea," is a product of the bast of the stingless nettle Boehmeria-tenacissima, while China-grass is derived from the bast of Boehmeria-nivea. Both species, however, belong to the nettle family, Urticaceae, and in view of the close relationship it is not remarkable that the structural characters are practically identical. For this reason they are usually classified under the one name, ramie. The shrub supplying the fibre grows from four to six feet in height, and thrives best in tropical and sub-tropical zones, and while it chiefly grows in China and India, the former country supplies the best qualities, where it also grows wild, covering large areas, so much so that it is far in excess of present requirements.

The properties of ramie are such as to place it in the first rank as compared with other vegetable fibres, and so far as length, strength, durability, colour, lustre, purity and susceptibility to deterioration is concerned, it it has no equal. The chief drawback to its general utility appears to be that the present methods of extracting the fibre for industrial use depends largely upon hand labour, which makes it altogether too expensive to compete favourably with other fibres. Nevertheless, in comparison with other vegetable fibres, ramie merits a much closer investigation regarding the development of an economical process whereby the fibres can be isolated from the soft tissues, thus placing it in a position to compete favourably with other bast fibres which are inferior and yet occupy a prominent position.

One of the outstanding characters is the extreme length of the cell-elements, a feature which varies from 50 mm. to 200 mm., while the diameter is also very irregular as between 0ʻ015 mm. and 0ʻ080. m.m.

The value of ramie will be appreciated when it is stated that it is being utilised with great success in blending with flax, resulting in materials which are equal to the best linen, while it is also used in some measure as a wool substitute.

———

SECTION III

Wool

The term "wool" is applied to the outer covering of various species of sheep, and also the woolly covering of various goats (e. g. mohair from the Angora goat), and the underdown of Camelidae (Bactrian camel, Andean alpaca, vicuna, etc.). To a very small extent other miscellaneous species, such as, the Angora rabbit and the musk-ox are included.

In common with all 'hair,' wool arises from a root or 'hair follicle' situated in the dermis or middle layer of the skin.

Though the same physiologically, fibres from the different species of wool-bearing animals show marked differences in form, and differences are also to be noted in fibres from different parts of the same animal. Three kinds of hair may be recorded in the sheep : (1) the true wool-hair, which is thin, soft curly, and possessing the valuable property of felting under the influence of water, soap and warmth; (2) the longer, stiff body hairs; and (3) on head and legs, a bristle hair which is devoid of the valued properties of wool.

Through countless generations of domestic sheep, a fleece has been evolved almost exclusively from the underdown of the primitive sheep. The primitive protective overhair occurs profusely in the wild sheep of Asia and Africa, and is common in mountain sheep. Careful breeding and favourable pastures can eliminate this stronger hair as in the merino sheep of Australia. However sheep, exposed to a rigorous climate on mountain or moor, re-develop the strong over hair freely in course of time. Presence of the two kinds of hair in a fleece is most objectionable from a manufacturing point of view. Such wools however sell cheaply for carpets and coarse makes.

It can be readily appreciated that there is variation between one fleece and another, even among sheep of the same flock. But there is also variation in staples from different parts of each fleece. Thus to obtain the best manufacturing results, detailed classing and sorting are necessary. The term "classing" is reserved for the operation of separating fleeces as a whole into different classes such as (1) longest, brightest and best, (2) same quality but less attractive, (3) rather stronger, etc. This is essentially an operation concerning the wool broker in his turn-over of wool, though, of course it is none the less advantageous to the manufacturer. Australian marketing in particular, recognises the value of careful classing, and lots are made up of ewe, hog , wether, lamb, etc. in each of the kinds indicated.

"Sorting" refers to the intimate separation of the different qualities in the individual fleece, and is best carried out by the manufacturer himself. Preliminary

classing may or may not have taken place, but is always helpful to the wool sorter. The number of qualities sorted depends upon whether the fleece has been trimmed or "skirted," and the lowest qualities removed, and also the purpose for which the wool is intended. In the case of fine Colonial merino fleeces, which are invariably skirted, no sorting may be required, or at most two sorts suffice, for woollen spinning. English fleeces, on the other hand, are commonly sorted into four to eight qualities. *In each fleece the finest staples occur on shoulders, back, flanks and qualities get coarser and poorer towards legs and belly.*

Trade terms were formerly used exclusively for the different sorts, but the custom is spreading of referring to the fineness of the staple by its Bradford quality number. This is an arbitrary assessment of the number of worsted hanks (each 560 yards) per ℔., which may reasonably be expected from the wool. More recently the British Wool Industries Research Association has endeavoured to correlate diameter of fibre to spinning power, but difficulty arises through fibres being not necessarily circular in cross-section. Actually a cross-section slightly elliptical improves the spinning power.

PHYSICAL PROPERTIES OF WOOL

The fibre diameter of wool varies within wider limits than any other textile fibre. Blackface, a coarse mountain wool indigenous to the higher parts of Scotland and the Pennines shows freely throughout the fleece strong fibres of 1/400 inch or coarser. Lustre wools

range around 1/550 in. diameter, finest Down wools
1/1000 in., finest merino 1/1800 in. Mohair is similar to
the lustre wools; vicuna on the other hand ranges
1/1800 1/2500 in., and is the finest of all wools; Cashmere
is rather coarser than vicuna; camel hair varies very
widely from 1/700 to 1/1500 in. These diameters
compare with silk fibres of between 1/800 in. (in the
case of strong tussah silk) and 1/2000 in. (from the
finest Bombyx mori). Cotton is usually confined
within the limits of 1/1200 and 1/1600 inch. In the
case of wool, the shorter fibres are the finer, whereas
with cotton, the longer are finer.

In common with the other textile fibres, wool is
hygroscopic, and may contain as much as 25% of its
weight in water without appearing damp. The standard
moisture content for clean wool is 16%, which may be
compared with 11% for silk and $8\frac{1}{2}$% for cotton. Dried
at 100° C, wool loses this moisture and assumes a harsh
feel; but on being allowed to lie in any ordinary humid
atmosphere it re-absorbs moisture and regains its
kindly handle. At 100° C. when in a moist condition,
wool becomes plastic; and if cooled without dis-
turbing the form assumed at the higher temperature,
this form is retained until the conditions of plasticity
recur. For instance, if the fibres be drawn out
and straightened, treated with moist steam or even
hot water, and allowed to cool in this straightened
condition, they acquire a straight "set" which is more
or less permanent. Such is the basis of crabbing
and steam-lustreing operations in woollen and worsted
finishing.

CHEMICAL CONSTITUTION AND PROPERTIES

The wool fibre, free from natural and acquired impurities, is a complex chemical substance termed "keratin." The assumption that keratin is one homogeneous substance is not warranted and indeed there appear to be atleast two distinct tissues, the one in the living cortex, and the other in the epithelial scales. Two proteins are obtainable from the wool substance, but whether these have a separate existence in the fibre or are clearage products of some higher protein is not known. Keratin contains the elements carbon, hydrogen, oxygen, nitrogen and sulphur. No definite figures are available as to the proportions in which these are present, though, concensus of investigators' results is the ratio $42 : 157 : 5 : 15$. The nitrogen content is found to vary slightly with different wools whilst the sulphur content is thought to be present in two forms, one of which is firmly combined and the other loosely combined.

At ordinary temperatures wool is to a certain extent water repellant, as shown by the fact that it is difficult to "wet out," but the prolonged action of boiling water tenders wool, initiates decomposition and loss in strength and elasticity, while small quantities of a substance termed "wool gelatine" pass into solution. In steam at 100°C., the fibre is attacked if the action is prolonged, and ultimately suffers loss in strength. Moderate treatment is sufficient, however, to impart increased affinity for certain dyestuffs which fact is made use of in dyeing mohairs which under ordinary conditions are difficult to dye. But this same property can be the cause of faults in blowing piece-goods previous to

4

dyeing, as the end nearest the cylinder is more drastically steamed and comes up darker on dyeing. Under the influence of moisture and moderate heat the wool fibre is apt to " mildew," such being most likely to occur when goods are allowed to lie in an alkaline condition as after scouring or after dyeing with vat dyes.

Dilute acids have little apparent effect on wool in the cold, but when boiled, the fibre absorbs a large percentage of the acid used, retains it tenaciously, and can then be dyed with an acid dye in a neutral bath. Treatment with dilute acids does not affect the fibre injuriously, and indeed with yarns it has been shown that these are actually stronger after the treatment. Wool is much less sensitive to acids than cotton or cellulose, and this distinction is utilised in removal of cotton or vegetable matter from wool on a commercial scale by " carbonising." Concentrated mineral acids completely destroy the fibre at moderate temperature, the action being nearly instantaneous in the case of nitric acid, sulphuric taking a little longer, and hydrochloric longer still. One remarkable action is the immersion of wool in cold concentrated acid for a few minutes then rinsing in running water Using sulphuric acid of 120-150° Tw. or hydrochloric acid of 29° Tw. at 20°C., the fibre swells slightly, is actually strengthened, and has no longer affinity for acid dyes. This is analogous to the acid treatment of cotton in producing vegetable parchment.

Wool absorbs alkalis from their cold dilute solution, although retention is less tenacious than with acid ; but if the temperature be raised the fibre is readily attacked and rendered harsh to handle. In the action

of alkalis, however, the temperature and period of immersion are very important. At 0°C. even concentrated solutions affect wool but slightly, if the period of immersion be short; but as the temperature is raised the action becomes more and more intense until at 100°C. a mere 1% of caustic alkali quickly destroys wool. Wool acquires an increased strength and lustre as well as a silky scroop, when rinsed in cold caustic soda (80° Tw·) but its affinity for basic dyes is lessened. The alkaline carbonates, Sodium Carbonate and Potassium carbonate, also tend to destry wool, although not to the same extent as the caustic alkalis. In dilute solution at moderate temperature they are used to a considerable extent as scouring agents ; but if the temperature be raised or the solution too strong, the wool is first of all yellowed and tendered, and on boiling may be completely dissolved.

The action of oxidising agents varies considerably with the agents and conditions. The principal agents used in textiles include potassium permanganate, sodium and potassium bichromate, chlorine, and hydrogen peroxide. Immersed in a solution of potassium permanganate, wool turns rapidly brown, and if the temperature be raised or the solution very concentrated the material is easily tendered. Permanganate in solution is occasionally used as a wool bleaching agent, whereby the pigment in the medulla is oxidised to a colourless compound and the brown deposit of manganese hydroxide removed by bisulphite treatment. Chromium is readily absorbed by wool from dilute solutions of the bichromates at boiling temperature and such is extensively used as a mordanting process for the application of " mordant " dyes which do not otherwise possess affinity for wool.

Under the ordinary conditions of mordanting, using dilute solutions, there is little destructive action on the fibre, but under more stringent conditons oxidising action asserts itself so that there is tendering, impairment of felting properties, and destruction of dyeing properties.

The action of chlorine is especially interesting and is wholly different from the bleaching effect so extensively applied to cotton. It is generally applied in the form of hypochlorite. With moderate treatment there is a swelling of the cortex, a smoothing out of the surface irregularities with increased lustre, and a marked diminution of felting properties. The process is commercially exploited in production of " unshrinkable " woollens, particularly woollen underwear. In the commercial process a proportion of the fibres are invariably seriously affected and, if the treatment has been carried to excess, white goods acquire a yellow tinge (which is removeable by bisulphite bleaching), and there is an increased affinity for many dyestuffs.

Hydrogen peroxide, on the other hand, appears to have no destructive action on the fibre substance but attacks the pigment matter rendering it colourless. It gives a permanent bleach and, being the best bleaching agent for wool, is being used increasingly for this purpose. The best sheep's wool is, of course, a good white, but many grades can be improved by bleaching treatment. However, in heavily pigmented wool and some of the rarer hairs such as camel hair, alpaca and vicuna, the pigment matter does not respond to this bleaching treatment, and these wools are accordingly used in their natural colour or dyed dark shades.

SECTION IV

Silk

Silk differs from all other textile fibres in that it is not composed of cells, but is the secretion of several substances from special glands of certain caterpillars belonging to the Lepidoptera or scale-winged insects. The main species of importance to commerce belongs to the section of Nocturna or night-flying moths, and the family Bombycidæ, the principal species being the mulberry worm (Bombyx-mori), which supplies the greatest quantity which comes into commerce.

In the spinning of the cocoon the glands of the silkworm exude a viscous fluid through two channels situated in the head of the worm, and so disposed that the issuing filaments run parallel at only a minute distance, from the head of the worm. Simultaneously with the exudation of the liquid silk (fibroin), two other glands begin to secrete a silk-glue (sericin) which con-solidates ultimately, giving rise to the characteristic appearance of natural silk. Upon emerging from the spinnerets, the viscous fluids rapidly coagulate when they come in contact with air.

The length of these double filaments varies between 400 and 1,300 yards. When placed under the microscope the raw fibres are readily distinguished by reason of the two filaments being held together by the external layer of silk-glue occurring in irregular masses upon the surface of the fibre, frequently the intervening spaces between the filaments of fibroin may be separated for considerable distances such spaces being filled in with sericin.

The filaments can be readily freed from the sericin by very careful scouring in soap solution or ammonia, when further examinatian will show that the individual filaments or brins are quite smooth and structureless, with occasional swellings and constrictions, while the separate brins appear cylindrical or triangular according to the position they occupied in the cocoon.

The fibres of Bombyx-mori very rarely show a striated appearance, but when striations are present they can be considerably emphasized by the application of dilute chromic acid solution, when it will be apparent that there are reasonable grounds for assuming a fibrillar structure, a feature, however, which is not necessarily due to any organic process. The latter feature is always a very marked character of wild silks. Cross-sections taken from the outer and inmost layers may be somewhat flattened or tariangular, while those taken from the middle of the cocoon are more rounded, the latter being the most suitable for reeling purposes, while the former is mostly waste.

Wild silk is much broader and coarser than cultivated silk, while the fibrillar nature is plainly evident, an additional feature being the presence of numerous

diagonal markings which often produce a distinct shadiness. These marks are very noticeable in Tussah and other wild silks, and is due to the overlapping of the fibres in the cocoon before the fibroin has completely set, consequently they are slightly flattened and thinner in such places, thus allowing a greater transmission of light.

The cross-sections of wild silks are flattened, sometimes wedge-shaped and show distinct fibrils with occasional minute air cavities intervening ; in other respects they are similar to cultivated silk in that they consist of two filaments of fibroin surrounded by a layer of sericin.

The diameter of cultivated silk ranges from 0·019 mm. to 9·030 mm. while the separate brins range from 0·009 mm. to 0·014 mm. The ribbon-width of wild silks ranges from 0·026 mm. to 0·036 mm., while the thickness is approximately 0·010 mm. From the above measurements it will be evident that there are marked differences regarding the size of various silks.

Silk possess, colour which ranges from white to dark yellow, but the colouring matter is in the sericin ; fibroin is white.

As may be expected, mulberry silk differs in its physical characters from wild silks and comparisons may most usefully be made with Tussah Silk.

Tussah silk, on the other hand, exhibits very distinct striations and transverse markings where the striations are almost invisible. The fibrillæ of Tussah

silk may be isolated by maceration in cold chromic acid. The colour of Tussah silk, too, is less easily removable by boiling off and ranges from white to rich orange. Some silks *e.g.* Japanese, are green. The Tussah silk fibre also differs from Bombyx in diameter, elasticity etc., as shown in the table below.

Name of silk.	Moth.	Country.	Diameter (in inches) of Inner Fibres.	Elasticity (inches in one foot) of Inner Fibres.	Tensile strength (drams) of Inner Fibres.
Mulberry.	Bombyx-mori	China	0·00071	1·9	2·6
Eria ...	Attacus-ricini	India	0·00093	2·0	3·0
Ailan-thus	Attacus-atlas.	India	0·00111	2 8	4·1
Tussah...	Antherea-mylitta	India	0·00172	2·7	7·8
Shantung.	Antherea-pernyi	China	0·00138	2·7	5·8
Japan (green)	Antherea-yamamai	Japan	0·00096	4·0	7 5

These are the figures for cocoon threads. Degummed or boiled-off silk is less by 30 per cent. in tensile strength and less elastic by 45 per cent. The Density, too, is affected by degumming, being 1·30—1·37 for cocoon thread and 1·25 for boiled-off fibre.

Silk is very hygroscopic and will absorb up to 30 per cent. of moisture and still have a dry feel and look. The average moisture content under ordinary conditions of temperature and humidity is about 9·9 per cent. which is equivalent to the official "regain" of 11 per cent on absolute dry weight. In common with most animal

fibres the strength and elasticity of silk decreases with increased moisture content.

Being a bad conductor of electricity, silk is readily electrified by friction, which tends to render it difficult to handle during manufacture. The trouble can be overcome to a great extent by keeping the atmosphere moist. The poor conductivity of silk is a property taken full advantage of in insulating wires used in electrical apparatus.

The most striking physical property of silk, perhaps, is its high lustre which appears fully after degumming. Processes such as dyeing and weighting deprive it of much lustre, but various means for restoration of this property exist such as simultaneously twisting and steaming the hanks under pressure.

Another property of silk, and one which was peculiar to this fibre until it was imitated more or less successfully in rayons, is what is termed its scroop—a crackling sound emitted when the fibre is squeezed or pressed. Scroop does not appear to be an inherent property of the silk fibre, but dependent upon the action of dilute acetic or tartaric acid.

CHEMICAL PROPERIES OF SILK

Composition :—According to Richardson, Mulberry silk has the following composition (Mathews loc. cit. p. 293) :—

Water	12·5 per cent.	Sericin	22·58 per cent.
Fats	0·14 per cent.	Fibroin	63·10 per cent.
Resins	0·56 per cent.	Mineral matters	1·12 per cent.

5

Both fibroin and sericin are proteins. The Elementary composition and empirical formulae of these substances being, according to Mulder, as follows :—

Fibroin C_{15} H_{23} N_5 O_6

Sericin C_{15} H_{25} N_5 O_8
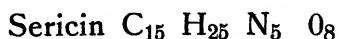
The average percentage analysis of Fibroin and Sericin are, given by Mulder and Bolley respectively, as follows :–

			Fibroin	Sericin
Carbon	...	...	42·60	44·32
Hydrogen	...	...	5·90	6·18
Oxygen	...	...	35·00	31·20
Nitrogen	...	...	16·50	18·30

Action of Water :—Distilled water has very little solvent action on fibroin ; at 100°C about 9·5 per cent. is found to be dissolved from 0·5 gram of fibroin by distilled water in three hours. The silk is a highly absorbent fibre and readily becomes impregnated or wetted by undistilled water. *Dissolved substances present in such water are rather readily absorbed or taken up by the silk ;* therefore, it is easy to understand that hard and impure waters are sources of contamination for silk goods with which these waters come into contaet during the process of washing, dyeing, or finishing. The softness and lustre of the fibre is quite easily affected by these impurities : consequently it is to be recommended that the water wherever it is employed in connection with silk, *be as soft as possible.* So thoroughly

is this fact realised at the present time that most modern silk factories use water softened by the zeolite process whereby the hardness may be reduced practically to zero. The character of the water employed in reeling silk from the cocoons is also said to have considerable influence on the quality of the silk produced. The best results are obtained when as soft a water as possible is used.

THE ACTION OF HEAT

In its general behaviour silk is similar to wool. It will stand a higher temperature, however, than wool without being damaged. It is not decomposed at 110°C but rapidly disintegrates at 170°C. The odour on burning is not like that of wool which contains sulphur.

THE ACTION OF ACIDS AND ALKALIS

The solvent action of acids and alkalis, in dilute solution is probably dependent upon the Hydrogen-ion concentration of the solution. In this connection the work of Denham and Brash on the Isoelectric Point of Silk-Fibroin is noteworthy. They concluded that the isoelectric point could not be quite definitely fixed but might be given as pH. 308. Rise of temperature accelerates the solvent action of dilute solutions of acids and alkalis on fibroin, which cold concentrated solution of these reagents quickly dissolve.

Special reference should be made to tannic acid for which silk has a strong affinity — wool has no such property—absorbing a large amount of the acid from cold solutions and as much as 25 per cent. of its weight

from a hot solution. The acid absorbed is not readily removed by water. The reaction of silk, wool, and cotton to concentrated Hydrochloric acid is sufficiently marked to be noteworthy. The acid rapidly dissolves silk—2 minutes gives complete solution—but in such time has little effect on wool or cotton. Silk is not as sensitive to the action of dilute alkalis as wool though its lustre is diminished. Strong hot caustic alkalis dissolve silk. The reactions of silk to metallic salts are definitely marked and are closely associated with the weighting of silk.

COMPARISON OF CHEMICAL PROPERTIES OF MULBERRY AND TUSSAH SILKS

The following table gives a good idea of the principal reactions of these two silks:—

REAGENT.	MULBEEY SILK.	TUSSAH SILK.
Hot Caustic Soda (10 per cent.)	Dissolves in 12 minutes.	Requires 50 minutes.
Cold Hydrochloric Acid (Sp. gr. 1.16.)	Dissolves very rapidly.	Only partially dissolves in 48 hours.
Cold Conc. Nitric Acid.	Dissolves in 5 minutes.	Dissolves in 10 minutes.
Neutral Solution of Zinc Chloride (Sp. gr. 1.725).	Dissolves very rapidly.	Dissolves slowly.
Strong Chromic Acid Solution in Water.	Dissolves very rapidly.	Dissolves very slowly.

SILK REELING

Reference has been made above to the manner in which the caterpillar spins its cocoon so that it is

capable under certain conditions of being unwound. Primarily it will be necessary to kill the chrysalis and secondarily, for economic reasons, to sort the cocoons.

Stifling the Chrysalis.—Several means are adopted for killing the chrysalis. The cocoons may be exposed to the direct rays of the sun; they may be heated for a few hours in an oven (Temperature from 60 deg. to 70 deg. C.); they may be steam heated in a specially built oven for a few minutes; and experiments have been carried out to ascertain the possibility of stifling the pupae by exposing them to the action of chloropicrin.

Sorting Cocoons.—This work, like that of sorting wool, is of the highest importance if silk of uniform character is to be secured. Defective cocoons which may be due to any one of several causes, are placed on one side by the sorters and are subsequently used as waste silk. Those cocoons that have passed into the accepted class are marketed as ready for the next stage-reeling.

Two channels for the conversion of silk into a textile material are available. The first is the recovery of the continuous filament of raw silk by Reeling and the second is the recovery of waste silk by Spinning.

Cocoon reeling is a very simple process but very tedious, on account of the fineness of the silk filament. The cocoons are placed in a water vat for steeping in order to soften the sericin. A mechanical brush is used for recovering the ends of the thread, which moves to and fro so that the cocoons adhere when the brush is drawn up at intervals. The cocoons are then transferred

to a trough containing water at a temperature of approxi mately 50 deg. F. The reeler takes hold of the required cocoon ends and draws them through the glass eyelet which forms the thread guide. From these the threads are passed over a small guide roller and finally through a guide ring which is moved from side to side at a high speed and winds the threads into hanks with cross winding. The reeler should see that the threads are free from knots and impurities, and must also increase or diminish the number of ends being doubled together in order to obtain raw silk thread of uniform count. Only the middle portion of the cocoon is reeled, the outer coating first spun by the worm is too coarse and uneven; the inner or last part spun by the worm is too fine. The thread thus produced known as "singles" is the raw silk of commerce and is removed from the reel and twisted into a hank or slips. These are made into small bundles called "books" and press-packed into bales of varying weights. Cocoons are reeled, of course, under various conditions, some being reeled in very primitive fashion by peasants in their own homes, others are reeled in factories called filatures and according to the place reeled. The silk is offered for sale undre different "chops" or grades.

SECTION V
Rayon (Artificial silk)

The various types of rayon are manufactured from cellulose.

In the manufacture of rayons it is essential that the raw material should be uniform, and it has so far been found practicable to use two sources of cellulose only, viz., wood pulp and cotton. It is estimated that about 85 per cent. of the world's production of rayon is from wood pulp, mainly spruce and pine, chiefly from Canada, Sweden, Norway and Finland. Spruce is the cheapest and best raw material for conversion into chemical wood pulp by the sulphite process. Canada is tha largest producer of sulphite wood pulp. Sweden produces bleached wood pulp from the pine and fir. The Norwegian spruce, owing to its slow growth is especially suitable for the manufacture of artificial silk, and Norwegian pulp has a high reputation for quality and uniformity. Finland is now manufacturing a high-grade cellulose containing only a small amount of ash. The length of the fibres makes it particularly suitable for the manufacture of the best qualities of rayon.

Cotton linters are also a source of cellulose in the manufacture of rayon. In certain processes, it is the most suitable raw material. The scoured and bleached Cotton waste is yet another form of raw material. Cotton is considered by some experts to be superior to wood pulp as a base for rayon manufacture. It can be affirmed that the breaking strain of artificial silk with a cotton basis is 25 per cent. higher than that of artificial silk produced from wood pulp.

Recent experiments have proved that flax also can be used in the manufacture of rayon. The waste fibrous material from the scutching and willowing processes is boiled and bleached as in the case of cotton linters, and the pulp produced is suitable for the making of high quality rayon filaments giving yarns of great strength and soft handle.

At present there are four principal methods of manufacturing rayon :

(1) CELLULOSE NITRATE PROCESS

This process is the oldest method for the production of rayon. Cotton is the most suitable raw material, and the process is, briefly, as follows : The wax, fat, and colouring matter are first extracted from the cotton by bleaching ; the linters are then washed, treated with chemicals, washed again and dried. The dried linters are converted into cellulose nitrate which in turn is dissolved in a mixture of alcohol and ether, a process requiring about 20 hours. The viscous collodion is filtered several times by being forced through a layer of cotton wadding covered by silkgauze enclosed by

tinned wire gauze. The air bubbles are next removed in order to render the filtered solution suitable for spinning. The solution is forced through a capillary orifice and on coming in contact with warm dry air coagulates immediately, forming the filaments. From 10 to 24 of these filaments are collected to form a stronger thread which is wound on to a wooden spool. As the solvents evaporate, the thread hardens. In wet spinning the collodion filaments are squeezed out into water or into a bath of sodium sulphate solution, which removes the alcohol and ether from the collodion. Cellulose nitrate must be converted into cellulose again owing to its great inflamability, and therefore a process of denitration by sodium hydrosulphite follows in order to prepare the filaments for commercial purposes.

Nitro-cellulose rayon is known under various names, such as Chardonnet, Collodion, Lehner, Pyroxylin, and Tubize. Under the microscope, dry spun cellulose nitrate silks show very few, but pronounced longitudinal striations. Wet spun collodion silks have a greater number of longitudinal striations than the dry spun type.

(2) CUPRAMMONIUM

In this process cellulose is dissolved in ammoniacal copper oxide. The resulting solution is filtered, de–aerated, and then spun into a liquid which reprecipitates the cellulose from the solvent.

Cotton is mostly used as the raw material for this process, although sulphite wood pulp was used quite successfully during the war. The linters, after being

boiled in a solution containing caustic soda and soda crystals, are washed and hydro-extracted. They are then bleached, washed, hydro-extracted, and stored damp. The spinning solution prepared by dissolving the cotton in cuprammonium solution, is first passed through three filter presses which remove solid particles and foreign matter. The air bubbles are next removed from the solution. In the Glanzstoff process the cuprammonium cellulose solution is forced through spinnerets (from 12 to 25 according to the count required) through a coagulating bath of caustic soda. This pressure spinning has now been largely supplanted by Thiele's stretch spinning process which produces filaments even rivalling in fineness those of natural silk.

(3) THE VISCOSE PROCESS

Of all rayons, viscose is manufactured on the largest scale. In this process wood pulp free from non-cellulosic materials such as lignin, resin, and gums is used almost exclusively.

At the rayon works the wood-pulp sheets are cut up into smaller pieces and treated with caustic soda ; when thoroughly saturated the caustic is run off, and the resultant mass, *i. e.*, alkali cellulose, is milled into white flocks and then allowed to mature for about 72 hours at 25°C. The ripe alkali cellulose is treated with carbon di-sulphide, and the whole is mixed in a rotating cylinder, the resultant gelatinous mass being known as cellulose-xanthate. The xanthate is next dissolved in a weak solution of caustic soda and forms a thick syrupy fluid known as "Viscose." The viscose is stirred for 90 hours at 150°C., at the end of which period it is filtered

through layers of cotton wool enclosed in fine cloth. The filtered spinning solution is allowed to ripen for a few days and then freed from air bubbles. It is next forced through fine jets shown in fig. 1 into a coagulating bath of sulphuric acid and sodium sulphate ; these jets of liquid viscose are thus converted into filaments of regenerated cellulose. The end of the spinneret contains from 12 to 40 (or more) perforations of about 0·1 mm. diameter, through which the viscose is squeezed out under a pressure of about 3 atmospheres.

A special after-treatment peculiar to viscose silk is desulphurising. This operation is carried out in hank form and alkali sulphides are used. Usually a bath is used containing about one per cent sodium sulphide at a temperature of 40-50°C. The operation may be complete in 15·20 minutes according to the character of the material used.

The filaments of viscose rayon may be identified by their numerous fine, and usually also some coarse, longitudinal striations. Hollow viscose rayon filaments are now being made and sold under the name of " Celta"; most of the imprisoned gas is extracted so that the filaments become deflated except where air bubbles form.

In the three processes already described, cellulose is used as the starting material and furnishes rayons, consisting essentially of cellulose again, i.e., regenerated cellulose. In certain other methods of production in which cellulose is used as the raw material, the final filaments consist of a compound of cellulose, and therefore possess properties different from the regenerated cellulose silks.

(4) CELLULOSE ACETATE

The first cellulose acetate silk produced in 1899 could not be dyed by any of the then known methods, and as it was expensive to produce, it found no practical application. The English acetate rayon was introduced commercially as "Calanese" in 1920 and the earlier difficulties in regard to dyeing were soon overcome.
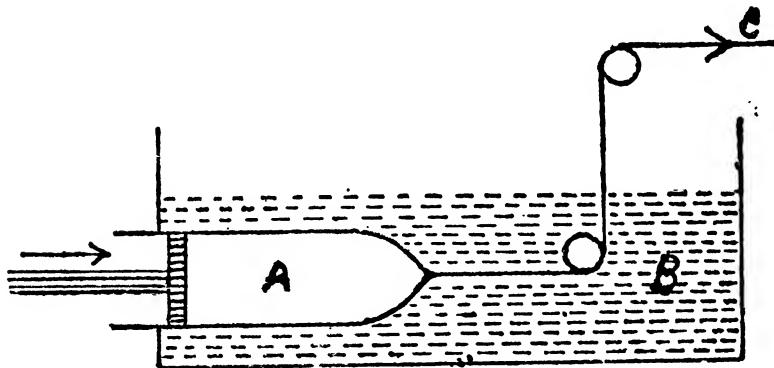
DIAGRAM

Fig. 1 (Spinnert)

A—Spinning solution forced through fine jest.
B—Coagulating medium (sulphuric acid and Sodium Sulphate Solution)
C—Filament.

The manufacture of cellulose acetate is in some respects comparable to the manufacture of cellulose nitrate silk. By suitable chemical treatment the cotton is converted into cellulose acetate which is then filtered and dried. The spinning solution is prepared by dissolving the mass in acetone, then filtering, and de-aerating. The solution is forced, vertically downwards, through circularly arranged single spinnerets or through a rose

spinneret. The filaments are gradually coagulated by a stream of warm dry air which passes up an enclosed vessel to meet the filaments as they emerge from the spinneret.

In addition to Celanese there are other cellulose acetate silks on the market, such as Rhodiaseta, Setilose, Lustron, Seraceta, etc. The microscopic appearance of the acetate, and all other rayons varies according to the method of spinning employed.

The fundamental principles in the production of rayons may be briefly stated. Firstly, the spinning solution must possess the property of tenacity and viscosity so that it can be drawn into fine filaments of great length. Further, it must be capable of producing a filament of sufficient strength and elasticity. The preparation of the solution depends upon the particular process to be used, but the ideal spinning solution for continuous production is one which has always the same composition and the same viscosity. In practice, however, this has so far proved unattainable.

Secondly, there must be a contrivance for forming and then gathering the filaments following coagulation.

Thirdly, there must be a suitable coagulating medium for the fixation of the filaments.

THE PROPERTIES OF RAYON—Artifical silks owe their properties, in part, to their chemical composition, and partly to the shape and thickness of the individual filaments. Those artificial silks which consist of regenerated cellulose, viz., cellulose nitrate, cuprammonium, and viscose silks, naturally differ from one another to a less extent than they do from cellulose acetate silk.

LUSTRE—Artificial silks usually possess a greater lustre than natural silk, but this excessive lustre is very often a defect rather than a merit. The various kinds of rayons differ among themselves in regard to lustre. Cellulose nitrate silks have a very vivid, glittering lustre; cuprammonium silks are less highly lustrous than either cellulose nitrate or viscose silks, and their lustre is of a more glassy character. Viscose possesses a very handsome lustre of a vivid, silvery type, and is quite free from glittering points. The fine filament cellulose acetate silks possess a lustre equal to that of natural silk.

HANDLE—Rayon made from coarse filaments feels much harsher than similarly twisted natural silk. The handle of the finest filament artificial silk is similar to that of natural silk, but less warm to the touch. As regards warmth, Celta and the cellulose acetate silks approximate fairly closely to natural silk.

SIZE OF FILAMENTS—Broadly speaking, the individual filaments of rayon are much thicker than those of natural silk. On the other hand, cuprammonium silk filaments produced by the stretch spinning process are even finer than those of natural silk. Again, Courtaulds' Dulenza yarn consists of 72 filaments per 150 denier, while the British Celanese Company are producing fine yarns of 2 denier filaments. But, as yet, filaments of such fineness are the exception rather than the rule.

EXTENSIBILITY—Rayon readily stretches beyond its recovery point so that a permanent increase in length occurs. It lacks true elasticity, *i. e.*, the power of returning to its original length after being stretched.

Even weighted natural silk possesses greater elasticity than rayon.

HYGROSCOPICITY—Rayon absorbs moisture from the air without feeling damp. Of the four main types of rayon, cellulose nitrate absorbs the most moisture and cellulose acetate the least ranging from about 12—4 per cent. Viscose and cuprammonium silks possess about the same absorptive capacity.

TENACITY—Tensile strength is the maximum strength with which the thread will resist its breaking when a straight pull is exerted. One of the defects of rayon is its low tensile strength when wet, which is only 35–55 per cent. of the tensile strength when dry, according to the variety. The best Egyptian cotton fibres have about twice the tensile strength of rayon filaments.

But in spite of certain serious defects, rayon is an independent textile of peculiar character, and has a great future. Recent improvements in the quality of the raw materials used together with a more careful control of the various processes have resulted in the production of filaments of very high quality. To-day, efforts are being made to increase the strength of the filaments when wet, to provide greater elasticity, and to prevent excessive elongation and there is little doubt that these efforts will meet with success.

Chapter II
Examination of Textile Fibres

Section I—Chemical Examination of Textile Fibres

Section II—Microscopic and Micro-Chemical examination of Textile fibres

Chemical examination of Textile fibres

Textile Fibres have been classified according to the following chart :—

FIBRES

```
                        FIBRES
                          |
        ┌─────────────────┼─────────────────┐
      Animal        "Animalised"        Vegetable
        |           Vegetable Fibre          |
   ┌────┼──────┬──────────┐                  |
  Wool  Hair   Fur      Silk                 |
                              ┌──────┬───────┼────────┬────────┐
                            Cotton  Flax   Jute     Ramie   Rayons
                              |
      ┌───────────┬──────────┐
  Mercerised  Immunised  Parchmentalised
                                      ┌────────────┬─────────┬────────┐
                                   Viscose  Cuprammonium  Acetate  Nitrate
```
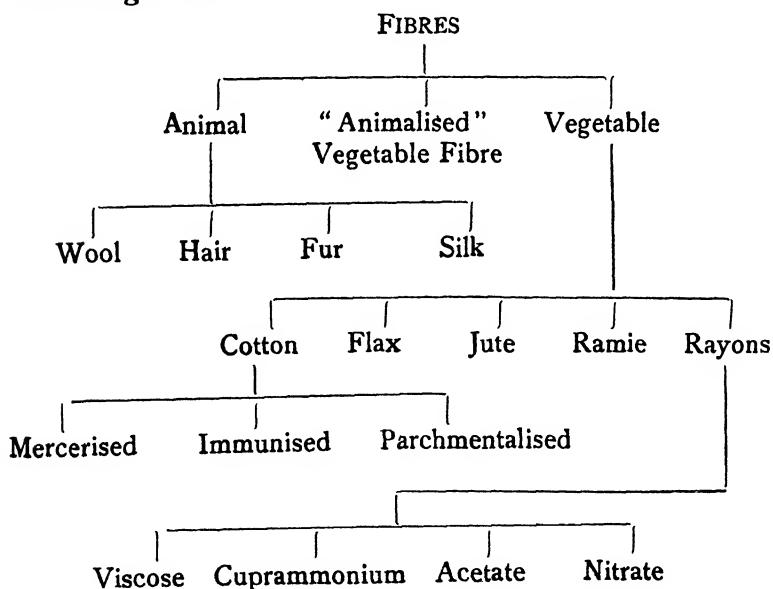
The Textile fibres are identified and analysed by means of—

(*a*) Chemical Examination.

(*b*) Microscopic and micro-chemical examination.

CHEMICAL EXAMINATION

The following tables give a detailed idea of the qualitative chemical examination of textile fibres.

Table 1

Experiment	Observation	Conclusion
1. Immerse a small portion of the sample in strong hydrochloric acid or nitric acid.	Completely decomposed and on drying forms a powder.	Cotton.
2. Treat with dilute sulphuric acid.	Blue stain.	Cotton.
3. Immerse the sample in a strong cold solution of zinc chloride distilled water and add off a few crystals of Iodine.	(1) Blue colouration but on washing the colour does not go away.	Mercerised cotton.
	(2) Blue colouration but on washing the colour goes away.	Un-mercerised cotton.
4. Wash the sample thoroughly to remove any traces of starch or size; make a solulion of iodine in cold Potassium Iodide solution and with this solution saturate the washed sample. Remove and wash well in water.	Bluish colouration; remains after washing.	Mercerised cotton.
	The sample remains white.	Un-mercerised cotton.
5. Treat and boil the sample with any of the following :—		

Experiment	Observation	Conclusion
	(1) Sample dissolved in (*a*), (*b*) and (*c*).	Silk.
(*a*) Hot caustic soda or caustic potash.	(2) Sample swells in (*b*).	Wool.
(*b*) Hydrochloric acid, nitric acid or sulphuric acid.	(3) Turns yellow with nitric acid in (*b*).	Wool.
(*c*) strong solution of zinc chloride.	(4) Sample dissolved in (*a*); add a few drops of Lead acetate and a black precipitate results.	Wool
NOTE :—Make an Iodine Solution as follows :— Ten grains Potassium iodide dissolved in 100 grain water, 1/10th grain Iodine added to it and the whole made up to a solution.		
6. Steep the sample in a part of Iodine solution for about 3 mins. Wash in a dilute sulphuric acid solution (10 grains $H_2 SO_4$ in 100 grains water) and wash twice to remove Iodine completely from the cloth.	(1) The colour of the sample turns to orange.	Jute.
	(2) The colour of the sample uneffected or little effected towards greenish grey colour.	Hemp.
	(3) Sample takes up blue shade.	Flax.
	(4) Sample takes up yellow colour.	New Zealand Flax.

Experiment	Observation	Conclusion
7. Subject the sample to a high steam pressure for some time, say 4 hours. Take out and wash in a steam chest.	Sample completely decomposed.	Jute.
8. Subject the sample to nitric acid vapours.	(1) Sample takes a dark red colour.	New Zealand flax and jute.
	(2) Sample takes a pale yellow colour.	Flax and hemp
9. Place the sample in a weak solution of sulphuric acid and add iodine.	1. Dark brown colouration of the sample.	Jute
	2. Blue colouration of the sample.	Rhea Fibre.
	3. Greenish yellow colouration of the sample.	Hemp
10. Add little Ammonia to the sample.	1. Orange shade of sample.	Hemp, if not retted.
	2. Violet shade of sample.	Hemp, if retted.

TESTS FOR ARTIFICIAL SILK (VISCOSE, CUPRAM-MONIUM, ACETATE & NITRATE RAYON).

Table II

Experiments	Observations	Conclusions
1. Treat the sample threads with acetone.	1. Threads dissolved.	Acetate Rayon.
	2. Threads not dissolved.	Viscose, Cuprammonium and Nitrate Rayon.
2. Treat the sample with $1_o/^o$ solution of Diphenylamine in pure sulphuric acid.	Deep colouration of the threads.	Nitrate Rayon.
	Threads unstained.	Viscose and cuprammonium Rayon.
3. A portion of the sample is treated with following solution:— (1% Silver Nitrate solution is added to 4% solution of sodium thio-sulphate and the precipitate which first forms is redissolved. 4% caustic soda solution is then added and the whole boiled and filtered.	1. Dark brown colouration of the threads.	Indication of Viscose.
	2. Threads unstained	Cuprammonium Rayon.
4. The sample is treated and immersed for five mins. at room temperature in a solution as follows:— 15 cc. Pelican ink No. 4001 (Gunther Wagner)	(1) Sample threads tinted pink.	Viscose.
	(2) Sample threads tinted to a blue or bluish violet shade.	Cuprammonium Rayon.

Experiment	Observation	Conclusion
20 c.c. $\frac{1}{2}$ % solution of Eosine Extra. 65 c.c. water.		
5. The sample is boiled for a few hours say about two hours in a diaphragm flask (the mouth of which is covered with filter paper soaked in a 10 solution of Lead Acetate) with acetic acid and sulphuric acid mixture.	(1) Brown or Black stain develops on the filter paper (formation of Lead Sulphide). (2) No Brown or Black stains produced.	Viscose. Cuprammonium.

BURNING TEST OF TEXTILE FIBRES

Table III

Experiments	Observation	Conclusion
Burn with match stick the fibre of which the sample is composed and note the burning carefully.	(1) If the fibre smoulders slowly and gives off fumes that smell like burnt horn. If the smoke reacts alkaline and turns litmus blue. If a small bead is also left at the end of the thread.	Animal fibres like wool and hair (The smell is due to sulphur, one of the constituents of animal fibres.)
	(2) If the fibre burns slowly and gives a disagreeable smell. Also leaves a charred ash as a small globule.	Silk.
	(3) If the fibre burns rapidly with flame, leaves a whitish ash in a thready form and gives less amount of smoke which reacts acidic *i.e.* turns blue litmus red.	Vegetable fibres like cotton, linen, flax.
	4 (*a*) If the fibre burns and charred end curls slightly.	Cotton.
	(*b*) If the fibre burns and charred end does not curl.	Linen, Flax.

TESTS FOR MIXTURES OF TEXTILE FIBRES

Table IV

Experiment	Observation	Conclusion
(*1*) *Cotton and Wool admixture :—*		
Boil the sample in a 5 % solution of caustic soda for 30 minutes when wool is entirely dissolved. Then add a few drops of Lead Acetate.	(*a*) A black precipitate. (*b*) A white precipitate only.	Wool present. Only cotton present.
(*2*) *Cotton and Linen admixture :—*		
(i) Soak the sample in methylene blue solution. Rinse in water.	(*a*) Threads that remain blue after thorough washing with water.	Linen.
	(*b*) Threads that give off colour on washing.	Cotton.
(ii) Remove a few threads from the sample.	(*a*) Long parallel threads (less twist).	Linen.
	(*b*) Small, not so parallel, threads (more twist).	Cotton.
(iii) Treat the sample with cold caustic soda and potash.	(*a*) Thread contracts but changes yellow orange.	Linen.
	(*b*) Thread contracts but remains grey colour.	Cotton.

Microscopic and Micro-chemical Examination of Textile Fibres

The Microscope : Its parts, Manipulation and Testing

For examining the yarn with a view to detecting the raw materials from which it has been spun, the so-called compound microscope (Fig 2) is employed. This consists principally of a tube closed at the upper end by a large, and at the lower end by a smaller, glass lens, with different focal lengths.

An object may be examined under a lens in two ways :—Either by bringing it within or beyond the focal length of the lens. In the former case, as is seen in the simple magnifying glass, an enlarged picture is obtained on the side next the object; but when the latter is at a distance greater than the focal length, the enlarged picture is formed in an inverted position on the opposite side of the lens. In the compound microscope both these conditions are combined, for the purpose of obtaining a very high power of magnification.

Of the two lenses referred to as terminating the microscope tube, the larger one with the greater focal

length is placed next the eye and the smaller one of lesser focal length nearest the object. The latter is therefore termed the objective and the former the eye-piece.

Eye-piece and objective are fitted in a tube some six to seven inches in length, capable of vertical move- ment, and blackened on the inside to exclude extraneous light. The object is first observed at a distance greater than the focal length of the objective, which for this reason is kept very small, whereupon an inverted magnified picture is projected at a certain distance inside the tube. At this place an annular diaphragm is inserted in the tube in order to limit the field of vision and exclude the circumferential rays tending to diminish the clearness of the picture. The length of the tube is so calculated that this picture falls within the focal length of the eye-piece at the upper end, whereby a re-enlarge- ment of the picture, is effected. The total magnifying power of a microscope is therefore the sum of the powers of the objective and the eye-piece.

To ensure clearness of the picture it is advisable to produce magnification chiefly by means of the objective. The latter is, as a rule, composed of several achromatic double lenses, the eye-piece consisting of a system composed of the true ocular lens and a collecting lens, the object of the latter being to enlarge the field of vision and increase the clearness of the picture, even though the size of the latter be simultaneously reduced. Were this lens not employed a portion of the rays proceeding from the picture would escape the eye-piece,
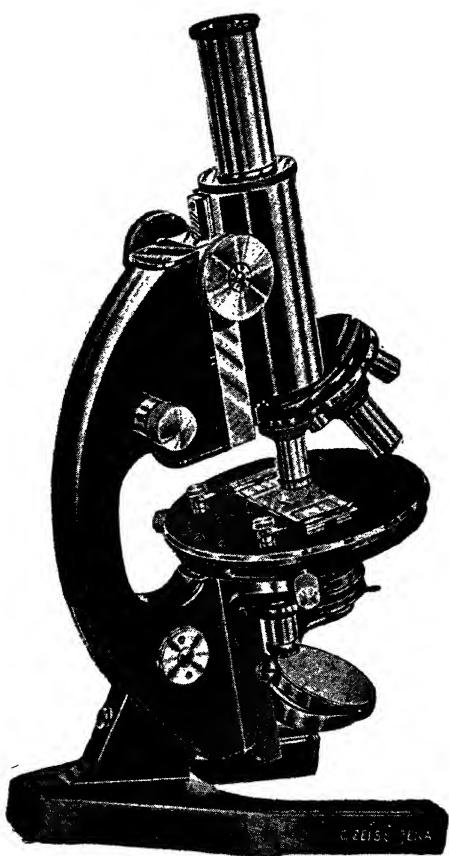
FIG. 2
The Compound Microscope

The tube carrying the eye-piece and objective can be raised and lowered by the hand (though for beginners the rack and pinion motion is more certain) to regulate the coarse or approximate adjustment, whilst the fine adjustment is effected by the so-called micrometer screw. On the stand is fixed an arrangement for supporting the stage, as well as one for supplying the necessary light to the object under examination, viz., the sub-stage condenser, a small circular concave reflector, movable in any direction. The stage is pierced with a small circular aperture for the passage of the reflected light, and may be either fixed or movable. The concentration of the light rays and the cutting off of the circumferential rays is effected by a revolving metal diaphragm fitted below the stage and perforated by several apertures of different diameters, their centres being equidistant from that of the diaphragm. For higher powers a cylindrical diaphragm is employed, consisting of a hollow cylinder, blackened on the inside, and affixed to the aperture in the stage. The best source of illumination is diffuse daylight with a sky evenly covered with a white veil of clouds. For evening work it is advisable to employ a glass bulb filled with a dark blue solution of ammoniacal copper oxide interposed between the source of light and the condenser.

When an object is to be examined by objectives of various powers in succession, use is made of a revolving objective-carrier or nose-piece screwed on to the lower end of the body tube, this arrangement facilitating the rapid change of powers.

The picture produced by the microscope must be very clear at the edges; the structural relationship of the

details of the object should be well defined, and the magnifying power must not be too low.

In judging the quality of a microscope the magnifyng power is not the sole consideration, the most important being the capacity of the lenses to produce a sharply defined and clear picture plainly showing all details of structure.

2. MAKING THE PREPARATIONS

Fabrics to be subjected to microscopic examination are first of all dissected into their individual fibres after removal by suitable means of all dirt, colouring matter, etc., so that the passage of the light will be unrestricted. It is advisable to immerse the object in water, or, better still, in a liquid like glycerine which will increase its transparency. A preliminary maceration of the fibres by prolonged boiling in water is very advantageous, and, in the case of vegetable fibres, boiling for a few seconds in nitric acid containing a little potassium chloride is recommended. The fibres are then laid on a glass slide (1 in. × 3 in.) separated one from another, but arranged side by side, and covered with a small circular or square cover glass (15 to 24 mm. in diameter and 0·15 to 0·20 mm. in thickness). To permanently preserve the preparation a drop of glycerine jelly is laid on the slide before applying the cover glass and warmed slightly by means of a lighted match held a little way below the cover, whereupon the liquid distributes evenly, and after gently pressing down the cover glass the whole is set to cool. The edges of the cover glass are coated over with black varnish. The subsidiary instruments used in these

operations consist of small knives (scalpels), needles, lancets, forceps and scissors.

3.   PREPARING SECTIONS

It is very often important to prepare sections in order to differentiate, for instance, between mature and immature cotton fibres, etc. To this end a number of the fibres are arranged parallel and embedded in melted tallow or paraffin, or a small bundle of the fibres can be impregnated with a thick solution of gum containing a little glycerine, the dried mass being firmly bound between two corks and a thin section cut by means of a smooth ground razor in a direction at right-angles to the axis of the fibres. A special apparatus known as the microtome, in which the knife moves in a guide frame and cuts the preparation through, at an acute angle, is also used.

The small sheet of paraffin is transferred to a slide, and, after being slightly warmed, the matrix is removed by turpentine or benzol. If the section is not sufficiently transparent it is steeped in glycerine or carbolic acid, etc.

4. THE MICROSCOPIC AND MICRO-CHEMICAL EXAMINATION

The simplest and best examination is performed by the microscope alone ; in case of doubt a micro-chemical test is also introduced, by admitting one or two drops of certain liquids under the cover glass and observing under the microscope, the reactions ensuing thereon.

In examining undyed fibres it is advisable, to pre-
viously steep or boil them in water, or if, as in the case
of wool, the fibres are contaminated by adherent fat,
to remove the latter by boiling with alcohol or treatment
with ether, carbon bisulphide, etc. Suitable reagents
for increasing the transparency should also be used.

In the case of coloured fibres, the dressing and
colouring matters should be removed by boiling in an
alkaline or weak acid bath, or by extraction with alcohol,
ether, etc.

(a) EXAMINATION OF COTTON FIBRE

The cotton hair may be regarded as a single attenuated cell originating from extremely minute papillae surrounding the outer layer of the ovules which may ultimately form the cotton seeds. When fertilization of the ovules is established these small papillae begin to rapidly develop in length for a definite period, meanwhile only primary cellulose and cuticle is formed. Having attained the full length, growth in length suddenly ceases, and a secondary deposition of cellulose along the walls of the hair gives rise to the " secondary cellulose, " which imparts to the cotton hair its peculiar thickening. An interesting factor concerning the cotton hair is firstly its peculiar thickening and secondly that during the time of its growth. the structure remains cylindrical, with a lumen or central canal running throughout, at least two-thirds of its length, the remaining portion gradually to a more or less solid apex. It is only when the hairs reach maturity that the typical characters are revealed, and are readily differentiated from all other types ; thus the appearance of the entire hairs usually presents a flat, ribbon-like band, more or less convoluted throughout its entire length, while such convolutions are very irregularly placed.

Examination of any portion of a single cotton hair may often show that the twists are by no means continuous in any one direction—that is to say, the twists may be axially left—or right-handed, or both, in one and the same hair, while interposed between such reversals may be relatively long portions that are quite flat. The edges of the hairs are somewhat thickened, giving the

9

appearance of a collapsed tube, whilst the central canal or lumen may be evident or obscure according to circumstances. At times the hairs may present the appearance of a smooth, flat ribbon with scarcely any thickened edge, with little suggestion of any internal structure.

Other features may exhibit cylindrical and apparently solid portions, or abnormalities in the shape of considerably swollen portions of the hair, probably due to irregularities during the growth of the cell. The typical appearance of normal cross-sections may be compared to that of a collapsed, tube viewed end-wise, but with thicker depositions of the edges while the flat portion is relatively thin. The presence of the central canal is also plainly evident, while in the interior may often be observed the remains of the once living protoplasm, the latter accounting in some measure for the presence of colour in many types of cotton, and often referred to as " endochrome. " Although all varieties of cotton appear to be somewhat similar to the casual observer, close attention to minute details will show that there are considerable differences, the best qualities which are capable of being spun into the finest yarns are those possessing the greatest hair length, and a corresponding decrease in diameter, while incidentally ·such qualities also show a greater number of convolutions per unit measurement than obtained, in low qualities.

Although the general characters of normal cotton hairs are fairly constant, it is nevertheless a fact that all samples of cotton will present a more or less quantity of hairs which have failed to develop beyond the stage

generally referred to as " growth in length, " and as a consequence, such hairs appear weak and brittle owing to the lack of thickening which normally takes place, and constitutes the undesirable dead, immature, or undeveloped hairs, according to the amount of thickening which has taken place. These usually show as very thin ribbon-like hairs, with little suggestion of convolutions, while the thickened edges peculiar to cotton may be entirely lacking.

Although the presence of undeveloped hairs in any appreciable quantity effectively lowers the quality, it is worthy of mention that recent investigation show that the presence of a small quantity of undeveloped hairs (not to be confused with short hairs) tends to yield a stronger and better yarn, a feature which is difficult to explain.

(b) EXAMINATION OF FLAX FIBRE

When examined under the microscope, the fibres are seen to be long, straight, transparent, and cylindrical and of fairly uniform thickness. They are, sometimes, longitudinally striated and exhibit periodic transverse cracks, nodes, and displacements, which give them an articulated appearance. The " nodes " are specially characteristic of flax fibres. Being of vegetable origin these fibres are organised and cellular. The cell walls are thick, the lumen narrow and the natural ends of the fibre are attenuated and sharp pointed.

The cross section is characteristic, being somewhat polygonal with the central lumen seen as a spot.

When the structural details are somewhat obscure the application of one drop of zinc-chlor-iodine (Schultze's solution) to the preparation will differentiate the nodes and fissures to a dark violet, the remaining portions of the walls being tinted violet according to the strength of the reagent, while the central canal is distinctly coloured yellow. The isolation of bast fibre elements can be readily attained by gently heating the fibres in dilute Hydrochloric acid solution.

(c) EXAMINATION OF JUTE FIBRE

As compared with other bast fibres the cell-elements of true jute are very short as they seldom attain more than 6 mm. in length, while the diameter as measured across the middle portion of the cells is fairly uniform, *e.g.* 0·019 mm. to 0·025 mm. While the nodes and transverse markings which are a distinct feature in most bast fibres, are entirely lacking in jute, the fibre walls appear quite smooth and lustrous.

The central cavity presents a remarkable appearance in that it varies considerably in diameter throughout the length of the cell, consequently the inner wall of the cell is very irregularly thickened and in many places they almost coalesce.

The fibres viewed in cross-section appear more or less polygonal and possess numerous sharp angles, while the lumen is circular, inclined to oval, and may be very irregularly placed regarding centrality owing to the variation of wall-thickness as viewed lengthwise.

The micro-chemical reactions of the raw fibres show that it is quite different in composition to either

flax or cotton, thus while cotton and flax are coloured blue, upon the application of sulphuric acid and iodine the jute fibres are coloured distinctly yellow to brown, a factor which is due to the presence of ligno cellulose as distinct from cellulose. Phloro-glucin followed by hydrochloric acid (dilute) will also verify the presence of ligno-cellulose in raw jute by changing the colour to deep red.

Since these reactions are dependent upon the amount of lignin which is present in the tissue of cells, any previous treatment to obtain a purer substance will result in a weaker colour reaction. An interesting feature concerning jute is that under careful treatment it can be made to yield a fine soft fibre admirably adapted for admixture with wool, and under such circumstances it is very difficult to recognize other than by careful microscopical analysis.

(d) EXAMINATION OF HEMP FIBRE

Hemp Fibre is seen to consist of cells which are fairly long, the average length being about 25 mm., but possesses a great variation between 5 mm., and 55 mm., while the diameter of the cells averages about 0·020 mm., the latter varying also between considerable limits, *i.e.*, 0·015 mm. in the finer fibres to 0·040 mm. in the larger elements.

A further similarity to flax is the presence of numerous joints and fissures, a feature which often obscures the details of the internal structure. The central canal is usually broad, but tapers off towards each end of the fibre, while the ends of the fibres are always blunt,

often slightly forked. Also the terminations of the fibres are usuaily very thick-walled as a consequence of the tapering lumen.

In cross-section the cells appear more or less rounded, possessing a rather broad collapsed lumen which is very often divided ; New Zealand flax is always round or oval.

A characteristic features which appears throughout the hemps generally is the presence of the blunt ended cells, which is apparently a difference of degree only, and while the common hemp is probably the most pronounced, New Zealand flax and manilla possess ends approximating those of flax. Nevertheless, several other characters are quite distinct. Distinctive microchemical reactions can only be regarded with any measure of certainty when dealing with the raw fibre, as any previous chemical treatment may have destroyed such particular element upon with the reaction depends. When treated with iodine and sulphuric acid, the raw fibres assume a green colour, while under similar circumstances flax assumes a blue colour.

(e) EXAMINATION OF RAMIE
AND CHINA GRASS

The structural characters are well marked and show considerable distances which are quite broad and flat, such portions being well differentiated by numerous longitudinal cracks or fissures, while the lumen in such places is difficult to discern. Other portions of the same fibre appear very narrow, more or less cylindrical, with very thick walls, while the lumen in such places

is usually well defined.   Both ends of the fibre are blunt, slightly swollen and very thick-walled.

The joints which are typical of most bast fibres are often very indistinct, but the presence of faint cross-lines appear very numerous.   The cross-section is quite characteristic in that the fibres are not agglutinated to the extent of other bast fibres, but are mostly single structures with prominent lumens, thick walls and are often laminated giving the appearance of several layers. The presence of numerous cracks or fissures radiating from the inner wall is also very characteristic.

Undeveloped fibres in a more or less quantity are a constant feature of all samples of ramie, and show up in cross-section as compacted masses of flat and very thin-walled elements.

The characters of ramie and China-grass are so much alike that it is difficult to make a distinction between the two fibres, nevertheless a distinction is at once apparent upon the application of aniline sulphate. With this re-agent true ramie fibre gives a yellowish colour, while China-grass remains unchanged, thus proving that the former is slightly lignified.

(f) EXAMINATION OF WOOL

Microscopic examination of a hair or wool fibre reveals a complicated cellular structure which does not admit of much comparison with the other textile fibres. At even moderately low magnifications three distinct portions can be identified: (1) a thick layer of fibrous cells or cortical tissue, surrounded by (2) an outer layer

of funnel-shaped epithelial scales of horn tissue, the free edges of which point towards the tip of the fibre, and (3) a central marrow or medulla which is present to a greater or less extent.

Individual fibres show these three constituents to a varying degree. Tensile strength and elasticity are acquired from the cortex. Merino Wools, and Cashmere from a Central Asiatic goat, which commonly show much cortex but no medulla, are intrinsically stronger and more springy than coarse wools in which the cortex is but slightly developed. Fine wools commonly show 25% extensibility which is rather more than silk and fully double that of cotton.

The surface scales are translucent in appearance and are more difficult to observe in the finer wools. The formation of these scales is inseparable from the degree of lustre exhibited by the fibre. Thus in the coarser wools, where the epithelial scales lie flat on the surface, there is comparatively regular and uniform reflection of light, and the condition is conducive to that degree of lustre associated with the lustre of Lincoln-wools, Leicester-wools and also mohair.— Cashmere and vicuna. The latter though very fine in diameter also have flat scales and are correspondingly lustrous. In merino wools, on the other hand, the scales are large relative to fibre diameter and protrude for as much as one-third of their length ; and merino wools in consequence are characteristically *less lustrous* Considered broadly, the lustre of wool is intermediate between the bright lustre of the rod-like structure of silk and the dull twisted fibre of cotton.

The medulla consists of slightly flattened cells rather larger than those of the cortex. Its dimensions vary widely with different hair and wool fibres. There is commonly much medulla in the stronger hairs and wools, while the medullary cavity is often absent entirely in fine wools. The medullary cells make little or no contribution to the tensile strength or elasticity of the fibre so that strength and elasticity vary inversely as the proportion of medulla in the fibre substance.

(g) EXAMINATION OF SILK FIBRE

Under the microscope, silk exhibits distinctive features whereby it may be distinguished from other fibres. Unlike wool, cotton, flax, etc., it is not of organised structure, and therefore not cellular in character. It is a smooth, structureless cylindrical filament, very regular in diameter though sometimes flattened and occasionally helical. In cross-section, under the microscope, the two brins are seen enclosed in a cloudy greenish or yellow integument. These parts have different chemical properties. They consist of chemical substances known as fibroin the (brins) and sericin (the gummy envelope). The sericin covering is hard and brittle and develops transverse cracks which the microscope clearly reveals. The brins exhibit marked polarisation colours, but these are practically non-existent in the sericin.

(h) EXAMINATION OF RAYONS

The rayon group of fibres are recognized and classified according to the way in which they are manufactured, and definite processes give rise to the several varieties

of rayon, namely, cuprammonium, nitrate, viscose, and acetate, while each type possesses characters peculiar to the process of manufacture.

Realizing the complexity of the nature of rayon the microscopical structure is somewhat misleading, and it is only within certain limits that a distinction is evident but by cautiously observing the form of the filaments along the axis of the fibres, and again in cross-section, they can generally be assigned to the type to which they belong. Similarly, by means of the polarizing attachment, each group of fibres yield interference colours which are most valuable in identifying the origin.

It is necessary to emphasize, however, that there are exceptions which do not conform to the general appearance of the group, therefore in such cases it is essential that accurate identification requires the addition of physical and chemical tests before a decisive conclusion can be arrived at, the latter usually depending upon traces of impurities carried forward during processing and which cannot be entirely eliminated.

Taking the types in the order given, the cuprammoniuum rayons are usually characterized by the extremely fine filaments, and are somewhat typical of the fibrine of natural silk, and being quite smooth and cylindrical they present a glossy appearance approaching that of degummed silk.

The nitrate, viscose and acetate groups all show a less degree of rotundity, while they are further characterized by the presence of numerous furrows running throughout the entire length. Such furrows or indenta-

tions can only be fully appreciated by obtaining cross-sections of the filaments, when it usually transpires that the nitrate group possesses the fewest number, followed by the acetate group, while the viscose group usually presents a large number of indentations, the latter being influenced by the temperature and concentration of the precipitation bath.

From such data the specialist can frequently determine the origin.
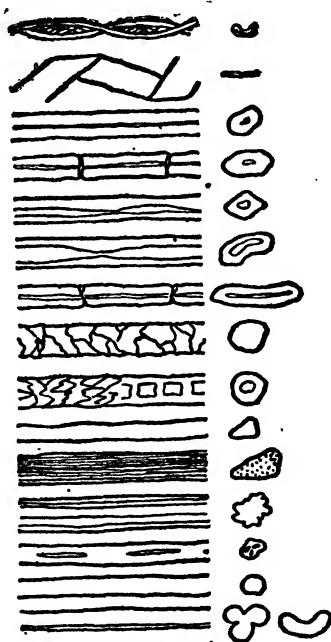
1. Cotton.
2. Sea Island Cotton.
3. Mercerised Cotton.
4. Flax.
5. Hemp.
6. Jute.
7. Ramie.
8. Wool.
9. Hair.
10. Silk.
11. Tussah Silk.
12. Viscose.
13. Nitrate Rayon.
14. Cuprammonium Rayon.
15. Celanese.

Fig 3

Microscopical Structures of Textile fibres including Rayon,

(5) MICRO-CHEMICAL TESTS FOR FLAX, HEMP AND JUTE

(*a*) Bleach the fibres, soak in a caustic alkali (2% Na OH) solution, rinse and dry, reduce fibre to pulp and spread out on a slide moistened with glycerine ; then treat with a drop or two of Iodine* and zinc chloride* solution. Examine under a microscope.

Colour turned yellow	...	... Jute.
Colour turned Red	...	... Hemp.
No colour ...	...	... Flax.

* Zinc chloride and Iodine solution is made as follows :—

To 100 parts of $ZnCl_2$ solution of 1·8 sp. gravity is added 12 parts of water and 6 parts of KI. Then add Iodine until vapours of the latter begin to form. Preserve away from light.

(*b*) Treat the fibre with Iodine solution only as above and examine under microscope.

Flax shows yellow circle surrounded by blue. Hemp has a yellow circle, interior surrounded by a thin transparent blue-greenish shade, seen where the two lots join. The nature and depth of green shade is determined by retting of the fibre. Jute shows a dark centre shading off into a yellowish colour.

(6) MICRO-CHEMICAL TESTS FOR COTTON AND LINEN.

The fibres of the sample are first dried at 100°c and steeped in either olive oil or rape seed oil for a minute or so. Afterwards the surplus oil is removed by placing

the fibres between two sheets of blotting paper. Examine under microscope.

The fibre is perfectly transparent ... Flax.

The fibre is opaque · ... ... Cotton.

(7) MICRO-CHEMICAL TESTS FOR WOOL, COTTON AND SILK

Prepare a solution as follows :—

2 grs. Na OH. dissolved in 30 c.c. water. Boil till clear. Cool to about 60°C. Add 3 grms. of Magenta dissolved in 5 c.c. alcohol. The solution is ready and is colourless. Make this solution up to 100 c.c. and filter.

Take a small part of this solution and boil the sample with this. Wash well and place in dilute solution of acetic acid, heat to 70° C. and dry.

Examine under microscope.

(*a*) Silk is coloured Red.

(*b*) Wool is coloured black or dark brown.

(*e*) Artificial silk, cotton and other vegetable fibres are not coloured and remain white.

(8) MICRO-CHEMICAL TESTS FOR VISCOSE, ACETATE, CUPRAMMONIUM AND NITRO-CELLULOSE, RAYONS '

The following table shows the various reactions :—

Test	Viscose	Acetate	Cupram-monium	Nitro-Cellulose
Burning ...	Burns rapidly, little ash, no odour.	Burns slowly, fuses, forms. a black shiny bead.	Burns rapidly, little ash, no odour.	Burns rapidly, little ash, no odour.
Acetone ...	Insoluble.	Dissolves readily.	Insoluble.	Insoluble.
Iodine-Potassium-Iodide.	Brown.	Golden yellow.	Light brown.	Dark reddish brown, almost black.
Chlor-Zinc-Iod. (Schultze's solution.	Violet.	Yellow.	Violet.	Violet.
Acid-Sulphuric and Diphenylamine	Dissolves slowly, no blue colour	Dissolves slowly, no blue colour	Dissolves slowly, no blue colour	Dissolves rapidly, deep blue colour.
Picro-carmine	No colour	Greenish yellow.	Red.	No colour.
Congo-Red	Strong red.	...	Weak colour.	...

Test	Viscose	Acetate	Cupram-monium	Nitro-Cellulose
Ruthenium-Red	Definitely pink.	...	Very weak colour.	...
Cuprammonium-solution (Sch-wietzer's Re-agent).	Dissolves rapidly.	Scarcely any action.	Dissolves very ra-pidly.	Dissolves slowly.
Ammoniacal-Sil-ver-Nitrate solution.	Coloured brown.	...	Remains uncoloured.	...

Chapter III—Yarn Testing

Section I—General examination including the strength and twists per inch.

Section II—Yarn counting system.

Section III—Count Estimation and conditioning of Yarn.

SECTION 1

General Examination including the strength and twists per inch

Testing of yarn appeals to men in different ways each according to their ideas.

The merchant looks for nothing in testing beyond the strength of the yarn. He observes the stretch but that is of little importance to him as its full value is not appreciated.

We have another class of men, the Spinner, who takes a pride in producing the best yarn he can either by spinning or by blending various raw materials. This man is particulary interested in the yarn in the following details :—

    (1)   Evenness and regularity

    (2)   Elasticity (stretch)

    (3)   Strength

    (4)   Twist per inch

    (5)   Colour-when of importance

    (6)   Counts

    (7)   Percentage of moisture

YARN EXAMINATION FOR QUALITY EVENNESS AND REGULARITY

It is necessary to examine yarn more closely for faults such as uneven places, knots, neps etc. Such fabrics as voiles, poplins, warp satins and fine brocades require a clean yarn. The evenness of yarn affects both the stretch and strength. The twist in an even yarn is uniformly distributed along its length and thus forces the fibre in each unit of length evenly together and makes each unit contribute its own share of stretch with a consequent great cumulative result. The strength is, therefore, greater not merely because the whole of the thread has approximately the same cross sectional area but because the fibres in such a thread are better arranged.

Machines such as figure (4) are used for examining the quality and evenness of yarn. The yarn is drawn from one or more cops or bobbins and uniformly spread over the dead black surface of a cardboard. The guider spreads the threads over this blackboard with sufficient space to enable defects to be seen.

Another type of machine is shown in figure (5) This machine is fitted with a sheet iron drum covered with black cloth. Yarn is wound from four cops at equal distances and traversed by the thread guiders through the action of the chain and cog wheel. The threads are examined during winding.

ELASTICITY AND STRENGTH.

It should first be defined what is understood by the term elasticity in textiles. Elasticity is the power of a
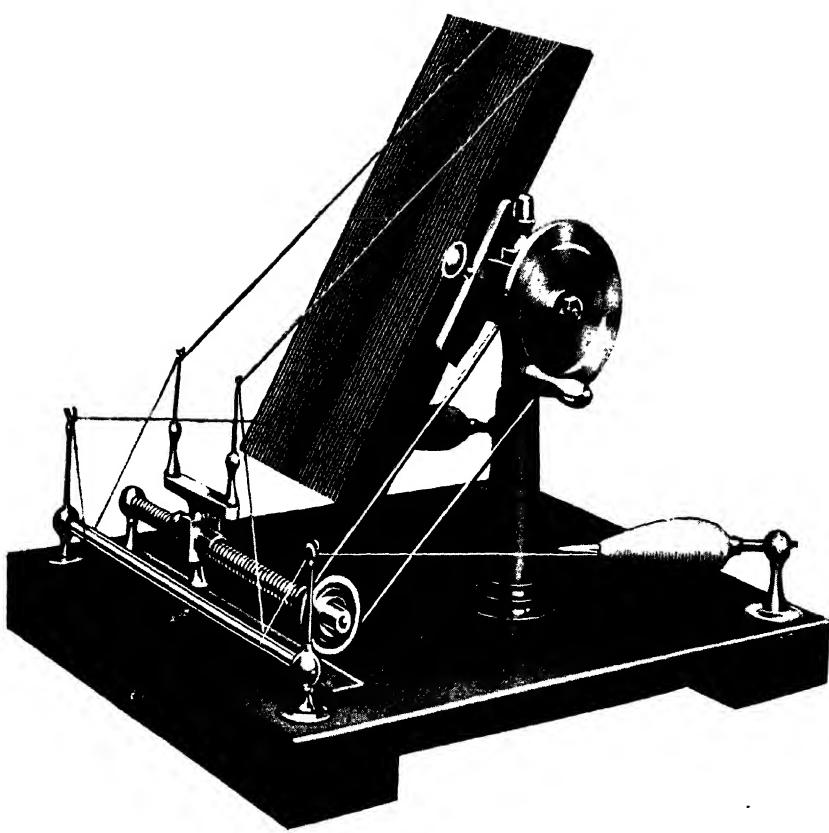
Fɪɢ. 4

Machine used for testing the quality and evenness of Yarn
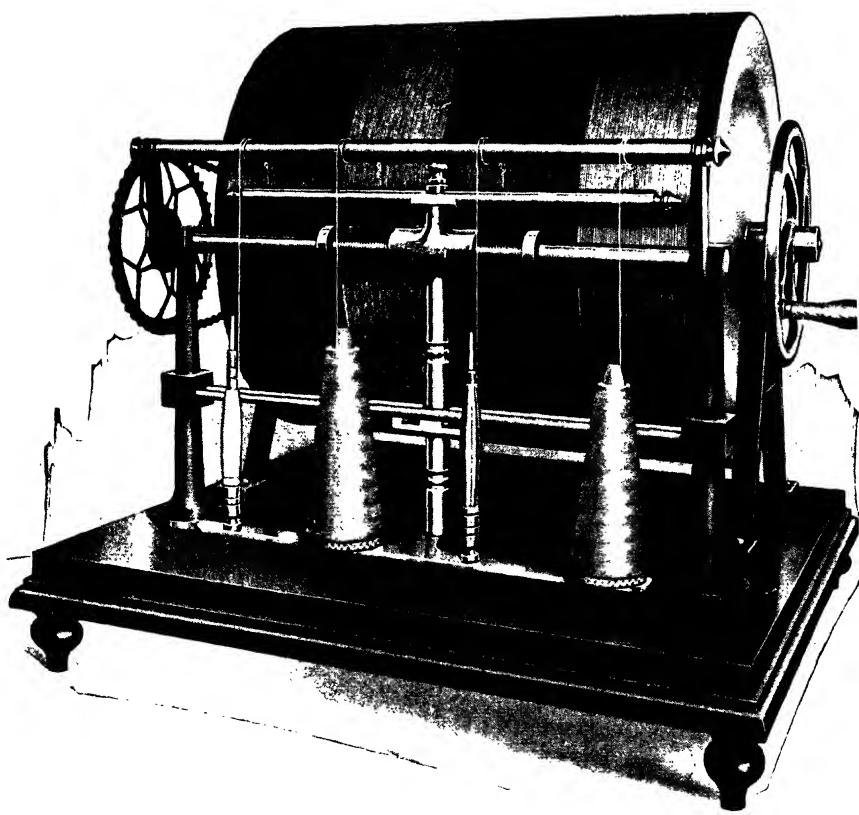
FIG. 5

Machine used for testing the quality and evenness of yarn (*Drum type*)

thread to recover its original length when the stretching force is removed. When a measure of elasticity is desired it should involve the idea of stress. That thread is more elastic which will stretch most and recover its original length as compared with others under similar stress.

The following factors affect the elasticity and the strength of the yarn :—

(1) Length of fibre.
(2) Fineness of fibre.
(3) Twist in the fibre.
(4) Whether or not it contains any natural wax.
(5) The hygroscopic and temperature conditions during production.
(6) The counts of the yarn.
(7) The twist in the yarn.
(8) The moisture the thread contains during testing.

Both the strength and stretch (elasticity) of the yarn is ascertained at the same time and in one operation on a type of machine known as lea tester.

The Test of elasticity of the yarn from the Lea Tester is by no means reliable and many firms and manufacturers ignore the method entirely.

Lea Testers, at the best, are only of a comparative-value, because they give no idea of the uniformity of the strength or stretch of the threads. Some are weaker than others and the strength obtained from a lea is only an average, the strongest threads assisting the weakest.

In weaving there is no assistance at all and here it is the proportion of weak places that determines the value of the yarn. Again, owing to the threads being bunched together on the hooks of the lea tester, there is strain applied to some threads before others. This fault is increased if the lea is carelessly reeled. For these reasons Lea or Hank testing is gradually been replaced by single thread testing.

By this system of testing accurate results both in the strength and the stretch of single yarns are obtained.

DEADWEIGHT LEVER LEA TESTERS
(FIG, 6, 7 AND 8)

These Machines are used for Testing the Strength and amount of Stretch of Cotton, Worsted, Linen or other Yarns, and Twines, etc., on the Deadweight Principle.

The shaft to which weight lever and roller are attached, rests on ball bearings, fitted in the head, or dial bracket. A sheet steel casing is fitted round the head bracket and bearings to keep out dust. etc. The upper hook is attached to lever roller by a strip of tempered spring steel. The lower hook has been designed so that the pull is in a direct vertical, line, and the position altered of slot in lower tube to obviate any liability of the yarn getting caught in revolving screw.

To make a test, the lea of yarn is placed upon the hooks, and as the lower hook travels downwards, the weight lever rises on quadrant rack in which the catches at end of the lever engage, and hold the lever and dial pointer stationary at breaking point, until released by
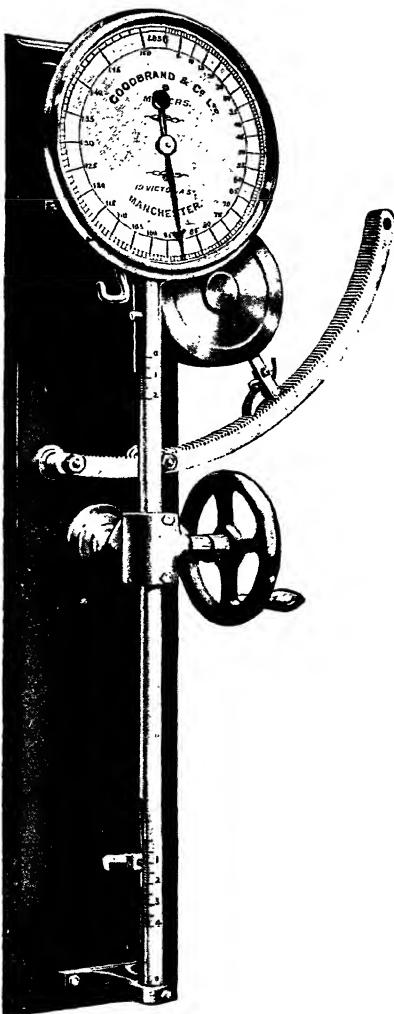
FIG 6

Deadweight lever Yarn tester (*Lea tester*) Hand Driven.

This Machine is worked by hand and is the usual type supplied to yarn agents and for use in Govt. offices or where power is not available. The dial is $12\frac{3}{4}''$ diameter and marked upto 150 lbs.
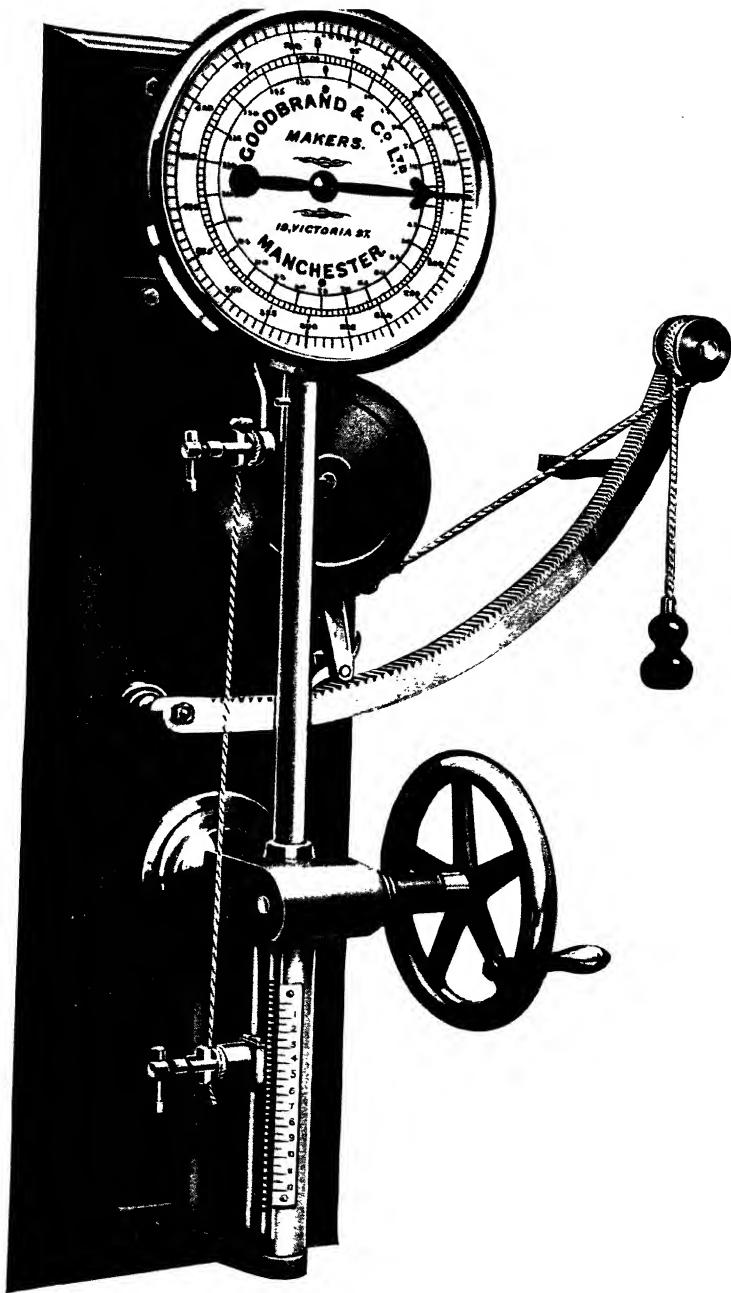
Fig. 7

Deadweight Lever Yarn tester for testing Twines, Cords and Thin ropes etc.
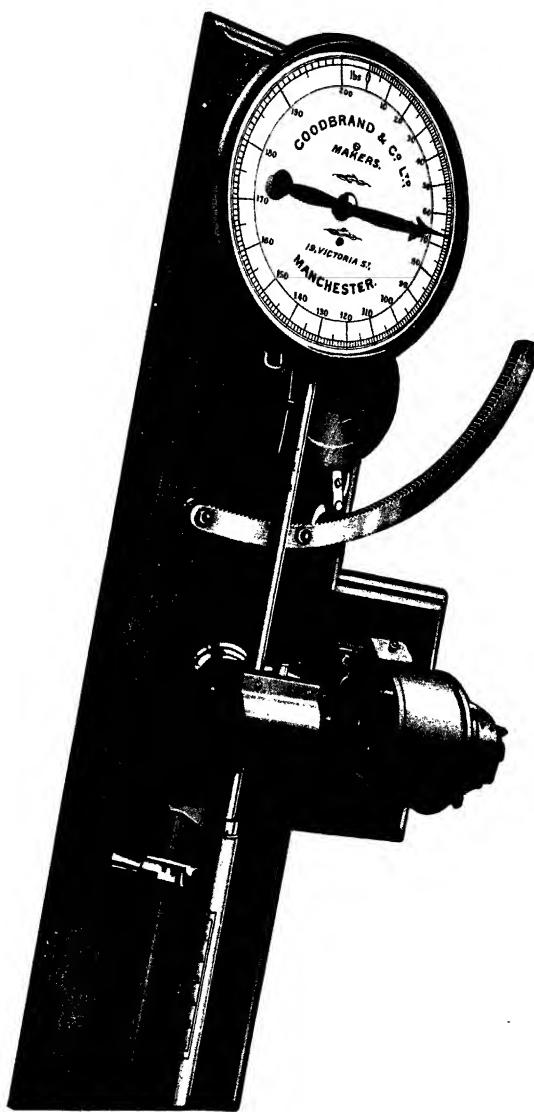
FIG 8

Deadweight Lever yarn tester for Cotton, Worsted,
Wool, Linen Etc. (*Power Driven*)

This is a motor-driven Strength Testing Machine

.

being raised. The stretch of the yarn before breaking, is indicated by pointers attached to each hook, on scales engraved on the brass tubes. The indicated traverse of upper hook is deducted from the traverse of lower hook, the result being the amount of stretch of the yarn.

Certain machines are made for working by hand and others by power, but the latter one is recommended as the results of tests on the latter, with a constant speed, are more even, and the averages more accurate than those shown when machine is worked by hand at varying speeds.

In comparing strength tests it is important that the speed of traverse of lower hook is alike in each case, the standard speed being 12″ per minute. Also the condition of moisture of the cops must be taken into account, tests from cops taken directly out of conditioning cellar show a greater breaking strain than those which have been for a while in testing room. Variations will result even between cops taken from the centre, and those taken from exposed upper portion of skip.

When the machines are set perfectly square and level, and pointer at zero, the accuracy can be tested by suspending a standrrd weight on end of a wire secured to upper hook. The wire must be sufficiently long for weight to hang below lower tube bracket. If indications are not correct, the pointer, which is on a cone centre, can be removed, set to correct position and tightened again. If necessary, the position of balance weight on lever can be altered as may be required,

METHOD OF WORKING OF THE OIL PLUNGE SINGLE THREAD TESTING MACHINE
(FIGS. 9 AND 10)

Raise the brass cap ' D ', (Fig 9) and fill the cylinder to within two inches of the top with good quality (mineral) spindle oil, moving the bottom carriage up and down meanwhile to expel any air. The carriage should descend quite smoothly if, however, it commences with a jerk, a little move oil will correct this.

The standard rate of traverse is 1 inch in five seconds and this can be regulated by turning the milled nut " E " which operates a needle valve in the oil plunger.

The sample to be tested should be first attached to grip ' A ' and afterwards to lower grip ' B ', only sufficient tension being applied to keep, the grip B in contact with the stretch rule. The attachment ' F ' can be fitted to the machine. This takes the place of the upper grip ' A ' and enables any length of sample from 6 inch to 24 inches (inch by inch) to be tested.

As soon as carriage is raised to starting point the weight lever is automatically locked at zero, and released as soon as carriage commences to descend. When the sample breaks, the stretch indicator is also released. By raising the carriage, the stretch indicator is again automatically connected up, ready for the next test.

TWISTS PER INCH

This term refers to the direction and number of turns of twists given to the yarn during spinning. Yarn that untwists when turning outwards when held between the thumb and finger of the hands is called " Twistway " and usually denotes warp yarn,
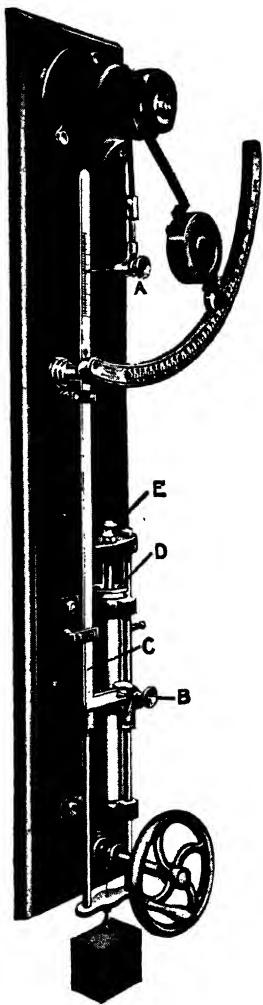
FIG. 9

Oil Plunge single thread testing machine

This is an oil-plunge single thread testing Machine, for testing single threads of yarn, cable yarns, linen, light twines etc. It is made on the dead-weight principle, with weight lever swinging in fine ballraces ; and a very fine cut rack with five independent catches, instantaneous re-setting motion with visible stretch reading.
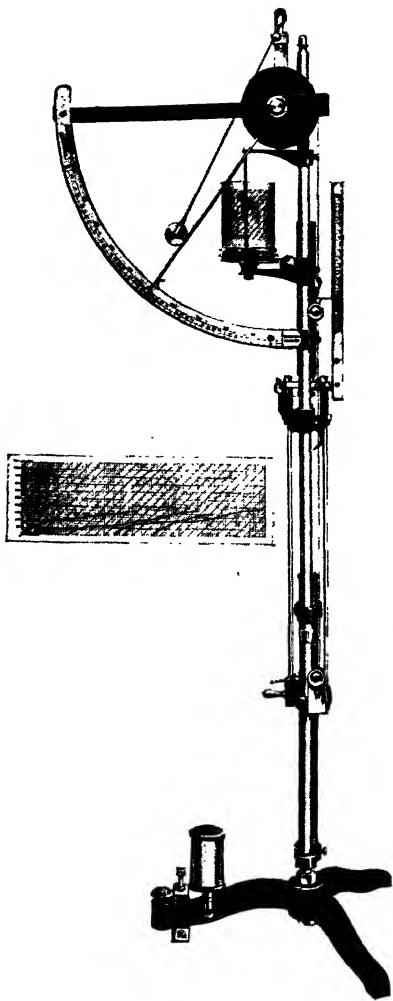
Fig. 10
Oil-Plunge single thread testing machine for single threads.

This represents oil-plunge single thread testing machine, for testing single threads of cotton, linen, woollen or silk yarns. This is fitted with a stress-strain diagram in addition to the usual dial and stretch plate. This diagram shows the characteristics of the yarn and enables a better comparison to be made between two or more samples whilst a permanent record is obtained for future reference. The recording attachment need not be used unless required and replacing of the diagrams can be quickly and easily done.

If it untwists when turned inward it is weftway and denotes weft yarn.

When twisting single yarn great care must be taken to see that the exact point is obtained when all the twist has been taken out.

Good quality yarn should have uniform twist throughout up to a point. The more the twist put into yarn during spinning, the stronger the yarn. Twisting beyond this point causes the fibre to be pulled past one another and weakens the yarn.

The machine most largely used for testing the amount of twist per inch in a doubled or multiple strand yarn is a Goodbrand twist tester, (Fig. 11), and consists of a 12 inch silvered brass bar, graduated in inches, to one end of which is fitted a fixed split jaw or grip. The 12 inches bar is grooved to carry the moveable jaw, dial and hand wheel which may be fixed in any position on the scale alluding to the length of yarn required to be tested.

To find the twist or number of turns per inch the dial is fixed at zero, the loose head clamped at the required position on the bar and the sample placed with one end in each pair of jaws. While the thread should be drawn taut it should not be stretched. Having gripped each end of the thread the hand wheel is turned until the twist has been taken out when the figure shown by the dial washer divided by the number of inches at which the machine was set will represent the twist per inch.

(Fig 12) is a machine used for testing the twist in both doubled and single yarn but more particularly in single yarn.

METHOD OF WORKING OF FIG 12 :—The twist in a single yarn is all removed when at greatest elongation. The non-twisting grip is therefore arranged to slide horizontally upon steel guides, and a tension lever, to which thread is attached, draws back the grip and keeps the thread taut throughout the test. The elongation of thread is indicated on sliding grip, and the number of twist turns indicated on dial.

To make a test, the dial is set to zero by means of milled nut and thread secured in twisting grip. It is then passed through open sliding grip, over guide pulley, and secured in end of tension lever, which is adjustable, to vary the amount of tension required. The sliding grip is then tightened and the hand wheel revolved.

For examination of the thread the machine is fitted with a powerful magnifying glass, with focussing pillar and nut, as shown in illustration, which can be quickly traversed full length between grips. The glass can be disengaged and at once removed to any point, or placed out of use altogether. A black tape fitted with spring coiler is drawn out and attached between grips, immediately under the thread, to facilitate examination.
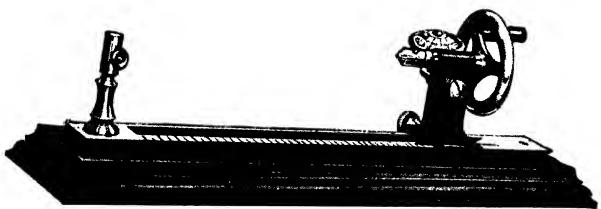
FIG. 11
Twist Tester for Doubled Yarns
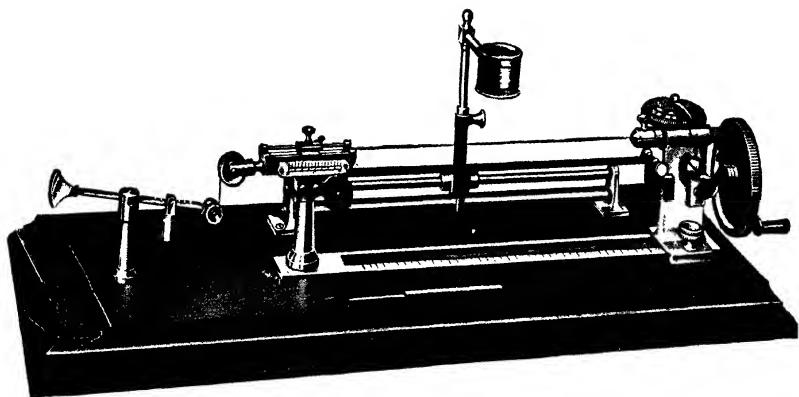
FIG. 12

Twist Tester for Doubled and Single yarns

SECTION II

Yarn Counting Systems

The methods of counting yarn in all cases deal with two factors—length and weight ; a given length of yarn which weighs a given weight is known as a count. The comparisons of length and weight vary according to the material under review. A considerable length and a fine weight are employed for fine yarn, while a heavier weight and a less distance are used for thicker counts. In some cases the yarn varies in its counts according to the variation of the weight—these yarns are known as the fixed length system and in other cases, the variation of the diameter of the yarn is proportionate to the variations of its length—this is the fixed weight system. In the fixed length system the counts of yarn are increased in proportion to the diameter of the yarn, a higher number denotes a thicker yarn, but in the fixed weight system a higher number denotes a finer count.

HANKS AND COUNTS.—These terms are used in all systems of counting yarns, and in order to prevent confusion, a clear definition of the term hank must be understood. The system of counting worsted yarns is one

where one hank of yarn which weighs a pound is called a 1ˢ (count). A 20ˢ consists of 20 × 560 yards to a pound. One pound of wool has been made into a yarn which is 560 yards long ; this is the worsted standard hank, and on this basis all worsted calculations are built up. The term "hank" which is used in the determination of the count must not be confused with the term "hank" used in the retail yarn trade. In hand knitting, wool hanks of yarn are made to weight, usually two-ounce hanks and half-pound bundles. These hanks are not standard hanks, and may or may not have the required 560 yards to the pound. It is not essential to have the yarn in hank form in order to obtain the measurement of 560 yards to the hank, the yarn may be on a bobbin or spool, or it may be in warp formation, and yet would be known in yarn calculations as hanks per pound.

COTTON COUNTS.—Cotton counts are counted on a fixed weight system, the weight used is 16 oz. The yarns are numbered according to the number of hanks of 840 yards contained in one pound weight of yarn. 840 yards of 1ˢ equals one pound.

This system of counting yarns is also used for spun-silk yarns ; these are yarns which are made from the waste of silk cocoons which could not be unwound, and produce organzine silk.

WORSTED COUNTS.—The number of hanks per pound of worsted is 560. A hank of yarn with 560 yards weighing one pound would be 1ˢ . This basis, is used for counting hair yarns spun on the worsted system

such as Alpaca, Camel hair, Cashmere, Mohair, and Rabbit Fur yarns. The worsted hank is two-thirds as long as the cotton hank; this forms a useful method of conversion. If 16,800 yards of worsted yarn weigh one pound the counts are 30^s $\left[\dfrac{16,800}{560} = 30^s \right]$

WOOLLEN SYSTEMS.—Several systems of counting woollen yarns exist today. The woollen industry gradually grew in many parts of British Isles and each district propagated its own system of yarn counting in order to deal the type of yarns made in the district. In many of these systems there is no common factor of length or weight. The woollen industry has three main centres in England and Scotland—the Scottish woollen centre around Hawich, the Yorkshire woollen district and the West of England woollen centre. The Scottish method of yarn numbering is based on the number of cuts which are each 300 yards long and weigh 24 ozs. The Yorkshire method was to find the number of skeins of 1,536 yards to one warton. A warton is a Yorkshire weight of six pounds, which was obtained from the old Yorkshire stone of 24 ℔s. The word "warton" was derived from a quarton or a quarter of a stone. The West of England method of yarn numbering was based on the number of snaps of 320 yards each in a pound. These three systems are the ones generally in use and there is a gradual movement to count all woollen yarns on the 256 yards to the pound system. The following details of woollen systems will give some idea of the many and diverse systems, and the difficulty in co-ordinating these under a common basis,

YORKSHIRE SKEINS :—These counts are now simplified into a yards-per-dram system of yarn counting. In order to bring the Yorkshire skeins system of yarn counting into line with fixed weight systems, 256 yds. are given as the basic length. 256 yds. of 1ˢ Yorkshire skeins will weigh one pound.

GALASHIELS SYSTEM :—These yarns are often expressed as Gala. cuts. The cuts are 300 yds. long, and the weight used is 24 ozs. In order to bring this system into line with other woollen systems, 200 yds. of 1ˢ can be said to weigh a pound.

WEST OF ENGLAND COUNTS :—The west of England system, counts yarns on the number of snaps of 320 yds. which weigh a pound ; therefore 320 yds. of 1ˢ weigh one pound. In testing these Yarns the number of 20yds. lengths required to weigh one ounce will give the counts.

The three general woollen systems are supplemented by several local systems ; these are :—

THE HAWICK SYSTEM :—this is a similar method of counting yarns to the Galashiels, but the fixed weight in the Hawick system is 26 ozs. as against the 24 ozs. in the Gala. cuts. In reducing the Hawick system into conformity with other woollen systems the following result is obtained. 184, 8/13 yds. of 1ˢ weigh a pound.

ALLOA YARNS :—The hand knitting trade often counts yarns on the Alloa system. The basis for counting is the number of spindles in 24 ℔s. A spindle in these yarns consists of 48 cuts of 240 yds. each. These

yarns were often made up in skeins of 120 yds. each, 12 skeins formed a head, and eight heads made a spindle of 96 skeins or 48 cuts or 1,520 yds., which weighed 24 ℔s. 480 yds. of 1's Alloa weighs 1 ℔.

LEICESTER LAMBSWOOL :—These are woollen yarns produced from short fine wool usually the early growth of wool on the sheep. The system of counting is 176 yds. of 1's weighing 1 ℔. In testing these yarns the number of 11-yds. lengths required to weigh one ounce is the counts.

DEWSBURY COUNTS :—The Heavy Woollen District of Yorkshire has its own system, of counting the thick woollen yarns produced in these districts. If the Yorkshire skein system was used for these counts several fractions of counts would be necessary ; in order to obviate this, a special system is used for thick yarns.

The number of yards weighing one ounce are the counts.

Sixteen yards of 1's counts (Dewsbury) equals 1℔.

ROCHDALE WOOLLENS :—The Rochdale system is a similar method of counting yarns to the Dewsbury system but instead of a yard per ounce system, a quarter ounce or four drams are used.

Sixty four yards of 1's counts Rochdale equals 1℔.

AMERICAN SYSTEMS:—There are two systems of counting woollen yarns in America, the Cut system and the Run system.

RUN SYSTEM :—The number of runs per pound is the count in the run system, a run has 1,600 yards.

1,600 yards of 1's counts (American Run) weigh 1℔.

AMERICAN CUT SYSTEM :—A cut has 300 yards, therefore, the number of cuts of 300 yards weighing a pound are the counts. This system is based on the same system as linen counts.

300 yards of 1's counts (American Cuts) weigh 1℔.

BUMP COTTON YARN COUNTS :—Very low cotton counts are not counted on the cotton yarn system, chiefly because the yarns are so thick that it would be necessary to express them in fractions of a count. The system used in dealing with these low cottons is to count them on the yards per ounce system. The number of yards of yarn which weigh one ounce is the count. If 40 yards weigh one ounce, the yarn is known as a 40's bump yarn.

The same method is employed in cotton yarns with low counts as with woollens. Cotton bump counts and Dewsbury woollen counts are both counted on the yards per ounce system.

LINEN COUNTS :—The method employed in dealing with linen counts has a base of 200 yards, to a lea or cut, which weighs a pound. The principle of counting linen yarns is the same as the cut system of counting woollens.

FIXED LENGTH SYSTEMS :—In dealing with fixed length systems, a higher number denotes a thicker count, a 100-denier silk is ten times as thick as a 10-denier silk.

There are two fixed length methods of counting silk yarns the dram system and the denier system.

The dram system of expressing silk counts is based on the fixed length of 1,000 yard. The counts are the

weight of the hank. A 1,000 yards hank of silk which weighs $4\frac{1}{4}$ drams would be expressed as a four and a quarter dram silk. In common with all fixed length systems a higher connotation denotes a thicker yarn— a $4\frac{1}{4}$ dram silk is a finer material than a 5 dram silk.

THE SILK DENIER SYSTEM :—This system is the oldest method of counting yarns, and dates back to the time when yarns were weighed by coins, the denier, against which the silk hank is weighed, was a small Roman coin.

The counts in this system are the number of denier that a hank consisting of 400 French ells will weigh. A French ell is 46·08 ins. long ; so 400 ells are equal to 512 yards. The weight of a denier is $\frac{1}{533\cdot3}$ of an ounce.

JUTE COUNTS :—In counting jute yarns the fixed length is known as a spindle. This consists of 48 cuts, or leas, which are each 300 yards. long. [$48 \times 300 = 14,400$ yards.]

The weight in pounds of one spindle of 14,400 yards are the counts. If 14,400 yards weigh 12 ℔s. the counts are 12's jute. This system is also used for counting hemp and heavy flax yarns.

RAW SILK YARN COUNTS—Raw or unwound silk is counted on the yards per ounce system. The number of yards per ounce are the counts of the yarn. 15,000 yds. of silk are found to weigh one ounce and the counts are 15, 000's yards per ounce silk.

EQUIVALENT COUNTS—In order to convert one system of counts into another system, the following formula is used :

$$\frac{\text{Present counts} \times \text{Present unit}}{\text{Required counts.}}$$

Twist Yarn—Single yarns are often folded together in order to give colour effects, or to strengthen the yarn for manufacturing processes. In expressing the counts of folded yarns, the single counts are used except in spun silk counts. A 2/60's yarn is a yarn where two single ends of 1/60's have been folded together. The weight of this yarn is twice as heavy as a 1/60's. In order to express the weight of the yarn a new term is used—this is " Resultant counts."

Resultant Counts—The Resultant counts of a twist yarn denotes the actual weight of the folded yarn, while the expression 2/60's denotes the composition, the resultant count of a 2/60's is 30's resultant count.

In the case of spun silk the folded resultant counts are expressed in this way : 60/2 spun silk denotes that a two-fold yarn of spun silk has been made from two 1/120's yarns.

Method Of Counting Resultant Counts—When single yarns of equal counts are folded together the following formula is used :—

$$\frac{\text{Single counts}}{\text{Number of ends.}} = \text{Resultant counts.}$$

The resultant counts of a 4/12's worsted yarn in

$$\frac{12}{4} = 3\text{'s}$$

When a 1/60's cotton is folded with a 1/48's cotton the resultant counts are obtained by dividing the product of the two single yarns by their sum.

$$\frac{60 \times 48}{60 + 48} = \frac{2,880}{108}$$

$$= 26\cdot6 \text{ resultant counts.}$$

When three or more yarns are folded together, another method may be used.

For example, the resultant counts of 1/48's, 1/36's and 1/24's are obtained by dividing the highest count by itself and again by each of the others. Add these results, and divide the highest count by the sum of the results in this way :—

$$\frac{48}{48} = 1$$

$$\frac{48}{36} = 1\cdot333$$

$$\frac{48}{24} = 2$$

$$\overline{4\cdot333}$$

$$\frac{48}{4\cdot333} = 11\text{'s.}$$

The resultant count of this yarn would be 11's.

Count Estimation and Conditioning of Yarn

The count of a yarn is simply determined by the quantity of length in a given weight.

The count is estimated both from long lengths of yarn and also short lengths of yarn. The former is obtained in lea or hank form and is the most common way of estimation by the spinner, and the latter is obtained from short samples of fabrics and is very widely used by warehousemen, Textile Inspectors and those dealing with the Finished Textile products.

ESTIMATION OF COUNTS WHERE LONG LENGTHS ARE OBTAINABLE :—In this case the counts are estimated from cop yarn, bobbin yarn or yarn in lea and hank form.

To make a test of a whole hank, skein or lea a wrap Reel is required which is used to measure off a definite length preparatory to weighing and testing. Figure (13) is a common type of wrap reel capable of reeling from four cops, bobbins, cones, tubes or hanks, at a time. The parts of the Reel which carry the cops and the thread guides have a traversing movement the object of which is to ensure that the yarn under test is

drawn evenly from the cop and screwed without over lapping across the arms of the swift, thus securing the maximum of accuracy in length.

In order to avoid the distortion of the circumference of the reel by careless handling or by removing the wrapped yarn too forcibly, strong rims, pinning together all the arms, are secured to the swift. The speed at which the handle is turned materially affects the result and very rapid reeling should be avoided, particularly when the yarn is being run off a Hank stand, as, in such a case, there is a risk of the hank stand over running the wrap Reel and giving too great length.

After measuring off a definite length of yarn on the wrap Reel, a good sensitive balance is required. A chemical balance with a glass protective case is the most suitable. The weights used should not be penny weights and grains but grains and decimals of grains only which will facilitate all forms of calculations. Having found the weight of the yarn, its count is calculated as follows:—

(1) *Count of cotton yarn*

$$= \frac{\text{Length weighed}}{\text{Wt. of length in grains}} \times \frac{7000 \text{ (grains)}}{840}$$

$$= \frac{\text{Length weighed}}{\text{Wt. of length in grains}} \times (8 \cdot 3)$$

(8·3 is known as a constant for cotton counts.)

(2) For Linen counts Reel 300 yards (which is one lea) weigh this and calculate the count as follows :—

$$Linen\ Count = \frac{\text{Length weighed}}{\text{Wt. of length in grains}} \times \frac{7000}{300}$$
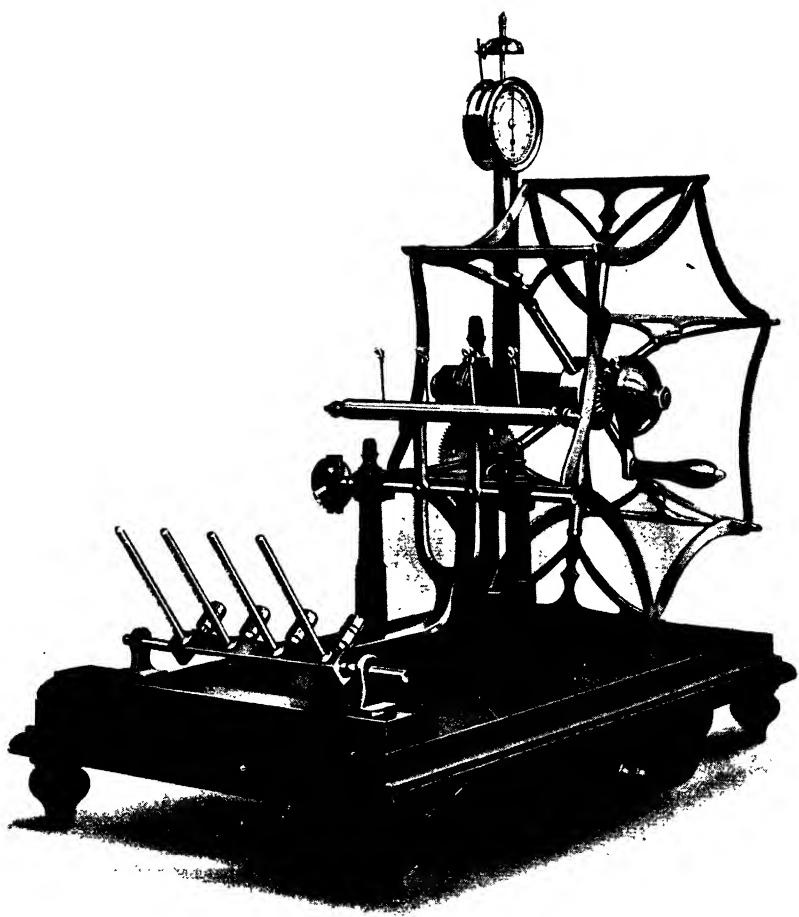
FIG. 13
Wrap Reel
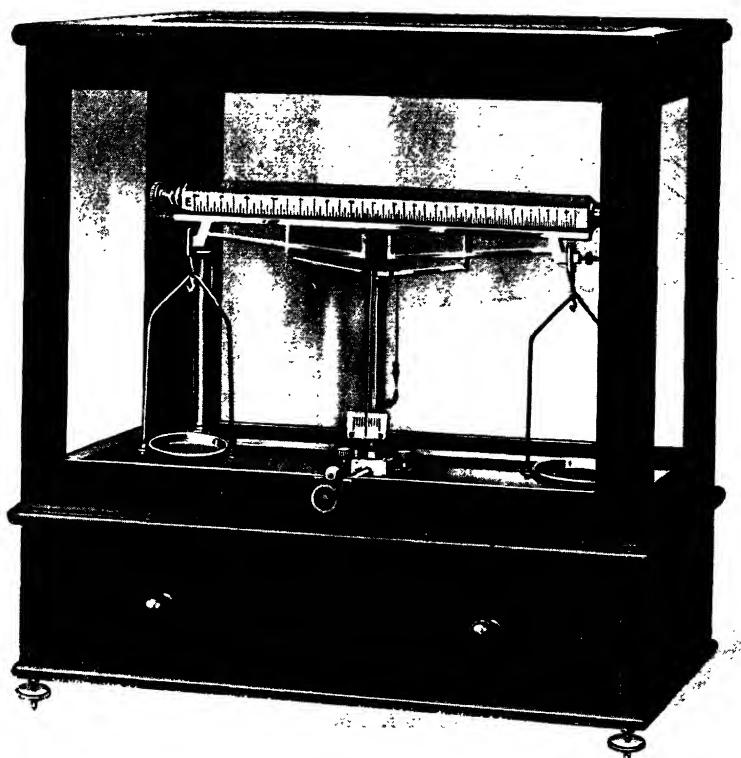
FIG 14.
Knowle's Yarn Balance

(3) For worsted counts; Reel 560 yards = (one skein), weigh this and calculate the Count as follows :—

$$Worsted\ Count = \frac{Length\ weighed}{Wt.\ of\ length\ in\ grains} \times \frac{7000}{560}$$

A quicker method of arriving at the required counts is to use either the Knowles yarn balance or Lancashire quadrant.

THE KNOWLE'S YARN BALANCE (FIG. 14) :—This is a very delicately balanced instrument and is very accurate; provided the operator is careful in his work. The balance is adopted to weigh up to 1500 gr. and sensitive to ·01 gr. The makers supply it with or without a glass case, but the one with the glass case is always advisable, to keep it free from dust or damage.

The counts of the yarn being tested are indicated on an engraved bar. These bars can be arranged to suit any range of counts and also for one or more less.

There are six faces engraved on a prism fixed behind the beam. The prism can be revolved, so that any of the six faces can be brought to the front. The faces are lettered, A, B, C, D, E, F. Face A will be engraved with the heaviest range of counts, say 20ˢ to 40ˢ, B will have 40ˢ to 60ˢ and so on up to 120ˢ. Circular weights marked to correspond with the faces on the prism are used, thus weight A is used when face A is at the front, and so on. These weights are placed in the left-hand pan and yarn in the right-hand pan.

Square rider weights also marked to correspond with the prism face are for use on the beam when weighing.

To operate the balance, place one lea of the yarn in the right-hand pan, and turn the face engraved with the range of counts you think the yarn will come under, say 40ˢ to 60ˢ , this face is marked B ; place circular weight B in the left-hand pan and square rider B on the beam, raise the beam by the lever, and if the pointer does not swing equally, move the rider to the right or left as required, until the balance is obtained. The line in the middle of the rider or indicator gives the counts on the face of the prism.

This machine can also be used as an ordinary balance by using grain weights. It is very useful to a spinner, or shipper dealing largely in yarns, as the counts are indicated quickly and without much calculation.

LANCASHIRE QUADRANT (FIG 15):—A quadrant is a very useful machine for estimating counts of yarn when a good length is obtainable. This is a reliable machine, but on this type of tester the scales are graduated for fixed lengths and only that length can be used, whereas with an ordinary balance or Knowles' any length and any weight can be used and with greater accuracy. Fig 15 has been specially designed for ascertaining the deniers of artificial silk. The indicating arms and beam are very sensitive. The double hook is arranged to take a hank (450 metres) and the dial plate engraved up to 500 deniers.

To operate the machine first test its balance and the pointer should rest at Zero. Wind a fixed length say I Hank (1 HK = 450 metres), suspend this upon the hook and the pointer swings to the Deniers of the yarn on the lower scale.
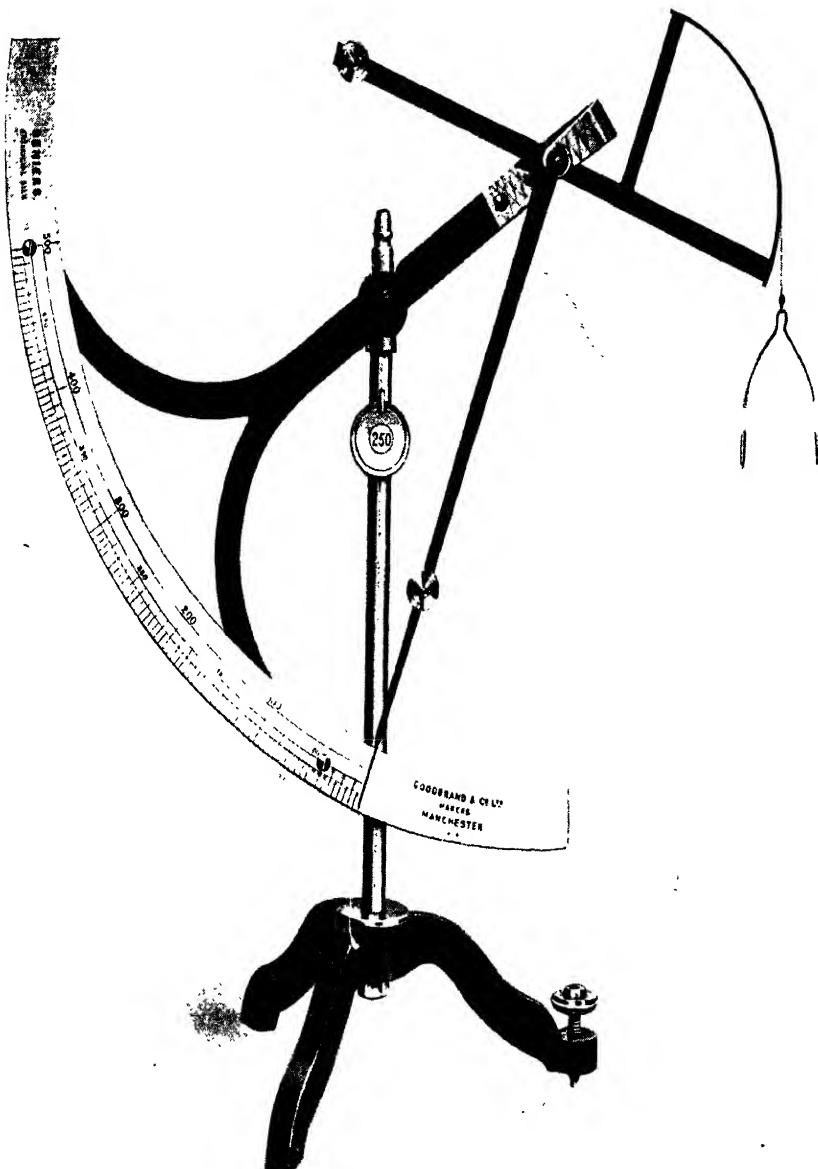
FIG. 15

Quadrant Balance for Artificial Silk
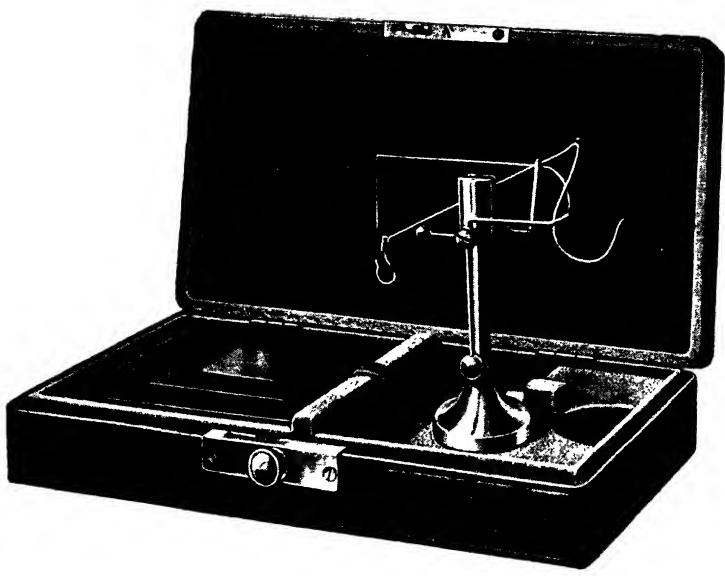
Fig. 16

Staub's Yarn Assorting Balance

ESTIMATION OF COUNTS WHERE ONLY SHORT LENGTHS OF THREAD IS OBTAINABLE

In making a test for counts from small patterns the weft and warp threads should be taken from places some distance apart to ensure a uniform test. The threads are then carefully measured, care being taken that all curl or waviness is straightened out as their length is ascertained. Then their total length is known and the weight of the threads in grains is determined. Great as are the difficulties in the way of testing the weft and warp threads, dissected from cloth, they are often needlessly added to by the fact that such very samples are submitted with an enquiry, the piece of cloth often measuring but three or four inches square. In such cases the most popular method of finding the counts is by the use of Staub's yarn assorting balance.

STAUB'S YARN ASSORTING BALANCE

This small instrument, shown in Fig. 16 is perhaps the most used of any tester for estimating counts of yarn from small patterns.

It is most realiable, and manufacturers and shippers use it very constantly. The cloth sample is cut to the respective template and a certain number of threads are drawn out and placed upon the scale beam on the right ; until a balance is obtained. The number of threads then on scale will indicate the counts of the yarn. The threads from most cloths will be slightly longer than template when withdrawn, being in a " wavy " line in the cloth, and for this a slight allowance must be made according to the kind of cloth. In a good cotton domestic cloth the allowance would be about

14

five per cent. or 1 count in 20. The background of balance is black, to facilitate observation.

Templates are supplied for other yarns, such as linen, woollen, worsted jute, etc. The template for cotton is under three inches wide, so that very small patterns can be tested.

BEESLEY'S YARN BALANCE

(For artificial silk)

Fig. 17 is a Beesley's· yarn Balance for ascertaining the denier of Artificial Silk yarn. The beam is engraved 50-400 deniers and a sliding weight is provided for the purpose of reading the deniers on the scale. The balance is made in two sizes *i.e.* for 9 metre samples and ½ metre samples. In the latter case a small template is provided measuring 50×25, m/ms. so that a small sample of cloth can be cut to this, when 10 ends of the long way or 20 of the narrow way drawn out of sample and suspended on the balance will give the denier.

Beesley's yarn balance is also made for ascertaining from small samples counts of cotton, woollen, worsted, silk and linen yarns.

CONDITIONING OF YARNS

The test for mositure in yarns is known as conditioning. The latter word is also used to signify the introducing of moisture into yarn either by the use of humidifiers or by exposure to a damp atmosphere. It is however, with the removal of that moisture and the calculation of its quantity and percentage that we are concerned. All Textile Fabrics are hygroscopic, or
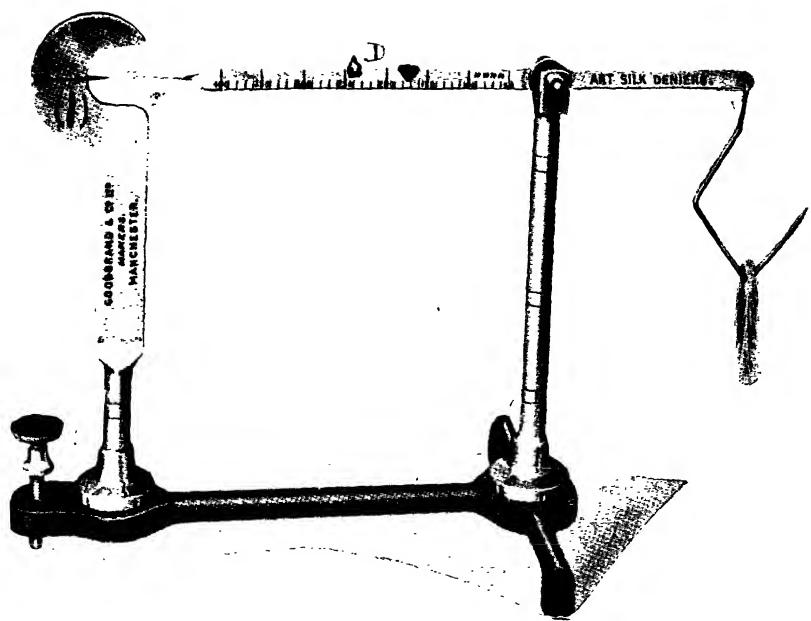
FIG. 17

Beesley's yarn Balance for Artificial Silk
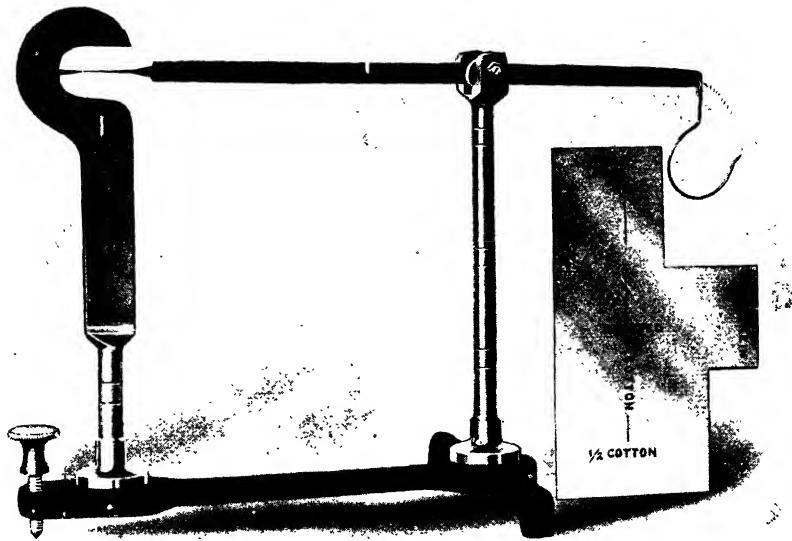
FIG. 17 B

Beesley's yarn Balance for ascertaining the exact counts of Cotton, Woollen, Worsted, silk and linen yarns. The pointer is set directly opposite the datum line on the scale by means of adjusting screw on the left of the machine.

Place the larger of the two hooks, supplied by the makers with this balance, in notch on left hand side of beam.

Cut the threads of yarn exactly to template length of material under test and place the same on yarn hook on right-hand side of beam.

Counts are indicated by the number of threads required to be placed on yarn hook in order to bring the pointer back again opposite the datum line. i.e. 30 threads of yarn=30s.

The template gauge marked "$\frac{1}{2}$ Cotton" is for use when only short lengths of Cotton yarns are available in which case the smaller hook supplied is used.

capable of absorbing moisture and, as such, materials are bought and sold by weight, the proportion of water contained in purchased quantity is, to the buyer, a highly important matter.

The capacity to hold moisture varies with different Textiles so that the standards in relation to which excess humidity is ascertained, vary in almost every trade. For example : wool and worsted, being more hygroscopic than cotton, the percentage of moisture regained after having been dried thoroughly, varies from 14% to 19%, according to whether it be noils, tops, carded, or otherwise, whereas in the case of raw cotton a regain of $8\frac{1}{2}$% is permitted. 100 parts of perfectly dry cotton yarn should, when exposed to the air for a sufficient length of time, absorb $8\frac{1}{2}$ parts of water. In other words, $108\frac{1}{2}$ parts of cotton in a normally humid condition should contain $8\frac{1}{2}$ parts of water, or a percentage of 7·834. Yarn may, and does frequently contain a higher percentage of moisture than 7·834, whilst still feeling quite dry to the touch, and thus it happens that, unless regular tests are made, a buyer often will receive water for the price of yarn.

The Testing Houses in England and the continent have paid much attention to this subject, and some particularly accurate research work has been done. These establishments are, therefore, very commonly called upon to perform tests for conditions which are carried out very carefully with the aid of the best available apparatus. The number of firms, however, who, in most cases, make their own tests is now rapidly on the increase, and, indeed, the cost of installing a good Conditioning Oven

with its accessories is so small that no large buyers of yarn should be without one.

The Test for condition, moreover, is not a highly technical operation. Care, of course, is required in this, as in all tests, but the apparatus needed is simple, and can be used without any special experience. A complete equipment consists of an oven varying in size according to requirements, upon which is mounted either a scale or Sensitive Balance. To one end of the scale beam is suspended a rod which passes through a small hole in the oven top. To this rod is attached the cage or reel which holds the sample during the test ; thus, the actual loss of weight by drying can be found without removing the yarn from the oven. The scale is in a state of equilibrium when either the reel or cage is attached to the hooked rod. By having the scale mounted on the top of the oven and completing the test before removing the sample, the correct dry weight is ascertained without having to expose the dried material to the humid air ; otherwise the yarn would immediately re-absorb some moisture and render the test inaccurate. Furthermore, the arrangement enables the operator to know at once when the drying process has ceased.

In addition to the hole through which the suspending rod passes, the oven top is provided with an aperture through which is passed a thermometer, by means of which the temperature of the drying chamber may be carefully watched during a test.

With the oven, the following accessories are required :—

A set of Brass Weights.

A Brass Reel for tops ·or material in hank form.

A Galvanized Iron Cage for wool noils, cops and loose or raw material.

A Thermometer graduated up to 300° Fahrenheit.

Ovens are made suitable for gas, steam, or electric heating. The Gas Oven has an outer case of iron and an inner chamber. The heat, furnished by means of a Bunsen burner, circulates freely round the intervening space, and ensures a uniform heat in all parts of the drying chamber. There are separate outlets for the fumes from the. Bunsen flame, and the moisture is driven out of the yarn.

In the Thermostat, a means of automatically regulating the supply of gas has been devised. This useful addition to a Conditioning Oven, which has also been arranged for electric power, maintains the heat at any required level. The Thermostatic control eliminates all risk of samples being scorched ; it also effects an appreciable saving in the amount of gas or electricity consumed, and releases the operator from the necessity of constantly examining the thermometer.

A Sensitive Balance totally enclosed in a glass case is also fitted to the Conditioning Ovens.

An Oven Heated by Electricity (Fig. 18) is regarded as preferable to the Gas Oven.

This system is more convenient, less liable to fire, and eliminates injurious fumes. The heating elements are fixed upon the base of the oven body and separated from the drying chamber by a perforated zinc damper. Two switches control the supply of current, so that after

using the maximum power to heat the oven quickly, one element may be dispensed with during the further progress of a test. Electric elements are wired to suit the particular current for which they are required.

METHOD OF TESTING FOR MOISTURE

If a test is to be made of yarn in hank from, it should be wound loosely round the Brass Reel; if cops, or materials in loose form are to be tested, the wire cage is used.

The reel (or cage), is then suspended upon the hooked rod attached to one end of the scale beam, and the oven lid placed into position.

Next, the sample is accurately weighed, after which the heat may be switched on. Care must be taken that the heat is not allowed to exceed 212° Fahrenheit when cotton is being tested. Should the test be upon wool or silk the temperatures may be brought up to 230° or 245° respectively. As heat is applied, the material in the oven will begin to lose weight and this loss of weight will, of course, continue until all moisture has disappeared.

A small pan is fixed to the rod which supports the cage or reel, and on this pan are placed weights sufficient to compensate for the loss of weight taking place in the sample under test. From time to time further weights are added until it is found that no further change is taking place. Thus, by finally bringing the scale to a state of exact balance the actual loss of weight is determined; this loss being equal to the weight of moisture present in the sample before the drying process begins.
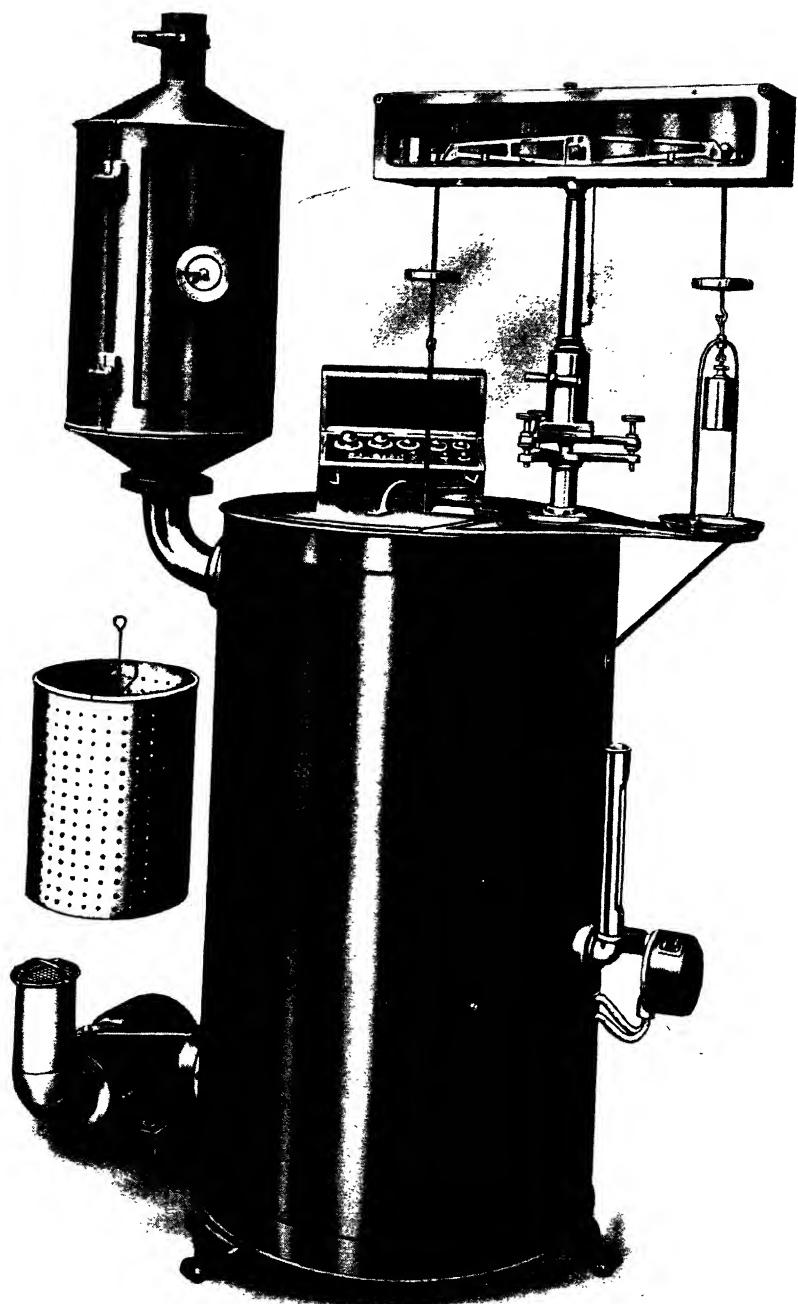
Suppose, then, that the original weight of a sample was 3 lb. and that, after bringing the yarn to a state of absolute dryness, it is found that 6 oz. must be added to what is known as the " goods end " of the scale in order to restore its balance, the direct loss in weight is equal to 6/48 oz., or 12½%.

The percentage thus expressed is, however, the amount of " direct loss " so that in order to be restored to its condition prior to making the test, the yarn would have to " regain " 14·29%. Now, the normal " regain " should be, as accepted throughout the cotton trade, only 8½%, which would equal about 3½ oz., in the 3 lb. sample. This would represent 2½ oz., of excess moisture in the original 3 lb. of yarn; which is nominally a five per cent. loss on purchases.

STANDARDS OF " REGAIN "

Accepted by European Testing and Conditioning Houses.

Material.		Amount of regain. Per cent.	Equivalent Direct Loss Per cent.
1.	Raw Wool and Waste	... 16	13·77
2.	Noils	... 14	· 12·30
3.	Noils (scoured)	... 16	13·77
4.	Tops ...	··· 18 to 19	15 to 16
5.	Worsted Yarn	... 18¼	15·50
6.	Carded wool	... 17	14·59
7.	Worsted and Woollen Clothes ...	16	13·77
8.	Silk ...	··· 11	9·86
9.	Cotton	··· 8½	7·91
10.	Flax and Hemp	... 12	10·71
11.	Spun Tow	··· 12½	11·11
12.	Jute	... 13¾	12·09

TESTING OF COTTON WASTE :

Fig. 19 is an apparatus designed by Mr. R. H. Harry Stanger of the Testing House, for London, a ascertaining the quality of Cotton Waste.

A given quantity of waste is placed on the needles in the upper part of the cage and by means of the Motor Mechanism, shaken up and down for a period of one minute at a speed of 280 Revs 1/ min. At the end of 1 min. the cage is reversed and the operation repeated. The sample is thoroughly disintegrated, the shorts falling on to a perforated slide of standard mesh and the fud falling on to a small drawer below. These two are then weighed and the percentage calculated clearly shows which is the best waste for a particular purpose.
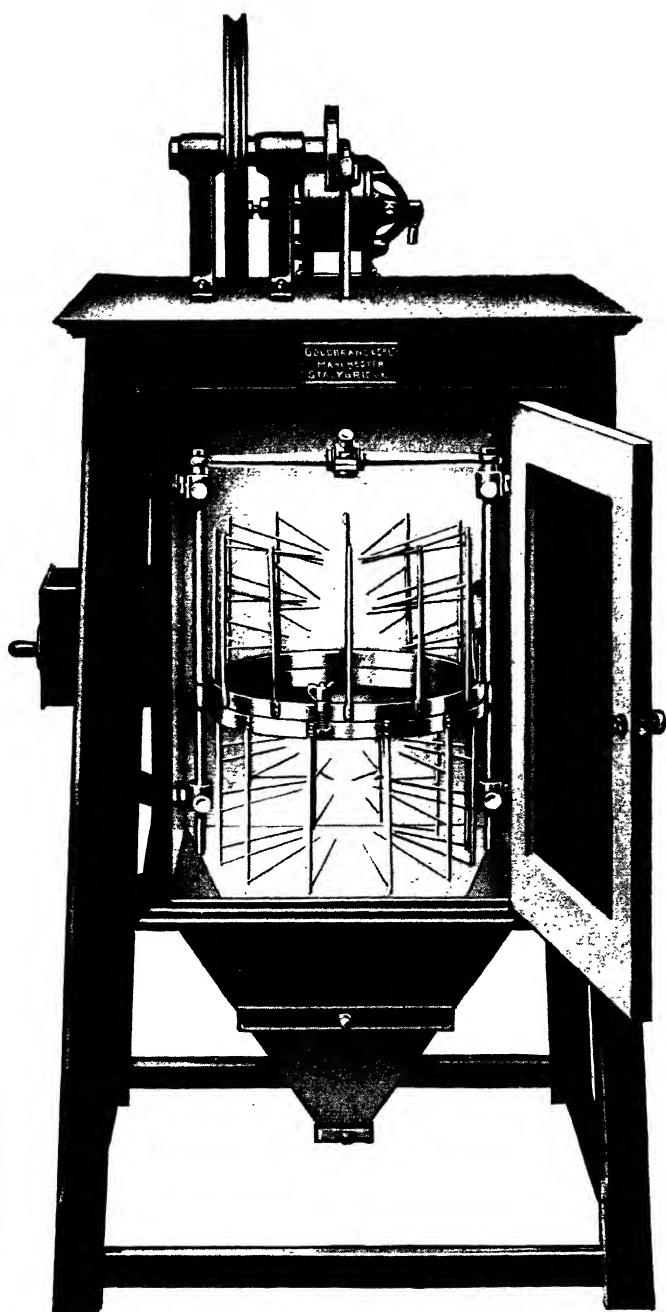
COTTON WASTE TESTER

Chapter IV

Testing of woven and knitted fabrics

Section I—Examination of woven fabrics

Section II—Analysis and Testing of knitted fabrics

Section III—Strength test of fabrics

.

SECTION I
Examination of woven fabrics

The object of cloth testing is to check and to determine as far as is possible the resistance of the cloth to wear. The most common tests made are weight per Unit area, determination of reeds and picks per inch, dissection of the weave, width and length of the cloth, shrinkage or regain due to weaving and the wearing test. Also it is very important to have a knowledge of common faults in grey and bleached piece goods. The strength test forms a very important item in cloth Examination and these are discussed in Section 3 of this chapter.

WEIGHT PER UNIT AREA :—This is usually returned in ounces (ozs.) per square yard. The best method appears to be to spread the cloth out flat on a smooth surface, so as to be free from creases and wrinkles. A template of known area, say 1/10th of a yard square, as shown in figure 20 is then pressed firmly on to the cloth, which is then cut round with a sharp knife or
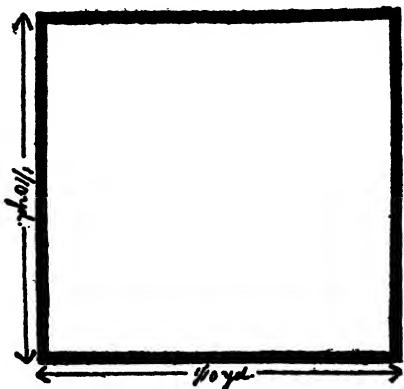
Fig 20.

scissors. The piece of cloth is weighed directly and the weight per unit area calculated as follows :—

Suppose the weight of cloth of the template size *i.e.* 1/10 yd. Square is x grains,

then   as 7000 grains = 16 oz.

$$x \text{ grains} = \left(\frac{16.x}{7000} \right) \text{ oz.}$$

This is the weight of an area of 1/100 sq. yds. of cloth. Therefore the weight of 1 sq. yard of cloth

$$= \frac{1\cancel{00}}{7 \cdot 0 \cancel{00}} \times 1 \cdot 6 \ x$$

$$= \cdot 228 \ (x) \text{ ozs.}$$

where ·228 is a constant.

Therefore to find weight per square yard of a cloth just weigh the sample piece of the template size in a chemical balance in grains and multilply it by ·228 and the result is given in ozs. The weight of cloth varies with the relative humidity of the atmosphere, and so it is better to dry the cloth to constant weight at 105°C before weighing. The dry weight of the cloth is then corrected to the 8·5 % standard regain. Unless the construction of the cloth is perfectly square, the shape of the template and the way it lies on the cloth will affect the result. Practice should therefore be standardised and a square template as shown above should invariably be used and it should be placed on the cloth with one side parallel to the selvedge.

DETERMINATION OF REEDS AND PICKS PER INCH :—

Before commencing to determine reeds and picks per inch, it is most essential to distinguish the warp from the weft in the woven fabrics.

The following are some of the methods of correctly deciding which is warp and which is weft.

(a) Find out if the sample has any selvedge. If so, thread, selvedge way, is the warp and the other weft.

(b) The twist way spun thread is usually warp, and weft way spun thread weft.

(c) The harder twisted of the two sets of threads is usually warp and the soft spun usually weft.

(d) In most fabrics the warp threads are straighter than the weft. (During weaving the weft con- tracts more than. the warp on account of tension being more readily applied lengthwise. to the cloth.)

(e) Warp threads are as a rule sized whereas weft is very seldom sized. This only applies to grey cloth and not to finished ones.

(f) Regularity in one set of threads shows warp and irregularity shows weft. Threads closer together show weft.

(g) Thread stronger than the other, although alike in other respects, is invariably the warp. The conditions of weaving are such that the yarn employed as warp must possess sufficient strength and elasticity to stand the strain of the loom whereas any material may be employed for weft which will hold together while the shuttle is carrying it across the open warp threads.

After distinguishing warp from weft, the determination of reeds and picks per inch should be made,

There are two methods generally used for this purpose :—

    (1) By means of a counting or pick glass whereby the warps and wefts are counted under a magnifying lens.

    (2) In case of double or fancy cloth the determination is done by dissecting the weave whereby the warps and wefts are taken out from a given size of cloth (Say 1″, both warp way and weft way) and the threads counted.

METHOD (1)—PICK GLASS.—There are many kinds of such glasses ·but the best is the cheapest in the end. The glass used must be absolutely accurate in measurement and the aperture must essentially be perfect, true as to size and its sides cut exactly parallel.

Pick glasses are made to suit different dimensions i.e ¼″, ½″ and 1″

Fig 21 shows a pick glass of ¼″ opening.

Fig. 22 is a travelling Pick glass known as ‘ Microscope ’ counting glass. It is fitted with a strong magnifying eye piece adjustable to any sight, combined with a fine pointer which is traversed along a divided plate by means of a thumb screw. The plate is marked on one side in inches and divisions and on the other in milmeters.

There is a modification of this type of pick glass in which the ‘ Microscope ’ is replaced by a constant double lens and the pointer is moved by a screw on one side of the plate which is marked in inches, and divisions of an

FIG., 2I
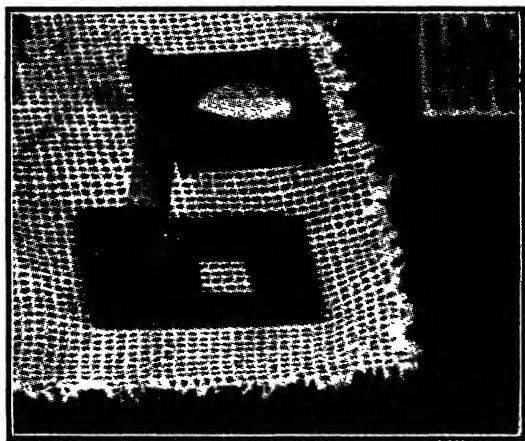
FIG. 22

Microscope counting glass

inch. This pick glass is pocketable and is widely used by persons engaged in the testing of fabrics. Great care should be taken in determining the reeds and picks as the counting depends upon the position of the first thread under the glass. Some persons count every thread that can be seen whilst others start with the first full thread. It is better to follow the latter course as it gives correct estimation of the number of reeds and picks per inch.

METHOD (2)—METHOD OF DISSECTING FOR WEAVE

This method is made use of in fabrics with complicated weave and where the counting glass cannot give an exact idea of the correct number of reeds and picks per inch. For fabrics, woven on Dobbies and Jacquards, this method is recommended.

First pull out a few weft threads so that any warp threads may be pulled out with ease. Next pull out a few warp threads to facilitate the pulling out of weft threads. Endeavour to separate with the aid of the dissecting needles (see fig. 23) the warps and wefts threads within 1 inch space (both warp way and weft way) and the number of threads so counted gives the reeds and picks per inch.

In order to transfer the woven design on to paper the following method may be adopted:—

Pull out picks so as to make a fringe on the top of the pattern. Cut away the fringe on the warp threads to a distance of about an inch, as shown at A (Fig. 24A.) This prevents the first thread B being displaced when

the picks are pulled out after following their interlacings. Place the forefinger of the left hand at point C and stretch the pattern tightly, holding it with the left hand as shown in Fig. 24B. By means of a sharp pencil-point, push a pick into the fringe, closely follow its interlacings with the threads and mark these on to point-paper until what appears more than one repeat of the plan has been obtained. Withdraw this pick, and push the next into the fringe and proceed as before, but mark the interlacings, on the point-paper on the next pick underneath the first one (see fig 24 C).

When once a thread has been decided on for the commencement of the weave, each subsequent reading of the interlacings must be started at this particular thread.

After having taken out a few picks, the analyst who is well versed in weave construction will most likely be able to complete the full design from the small portion obtained by " picking for weave, " but in the case of the beginner it is better to follow the interlacings of threads until a complete repeat of the plan has been indicated on the point-paper.

WIDTH AND LENGTH OF CLOTH

It is a known fact that the cloth contracts after leaving the loom and that the amount of contraction varies with the weave and the tension on the warp whilst in the loom. Humidity has also a good effect on the dimensions of the cloth. When measuring length and width of cloth, sufficient allowance must be made for this contraction, in order to avoid friction between the
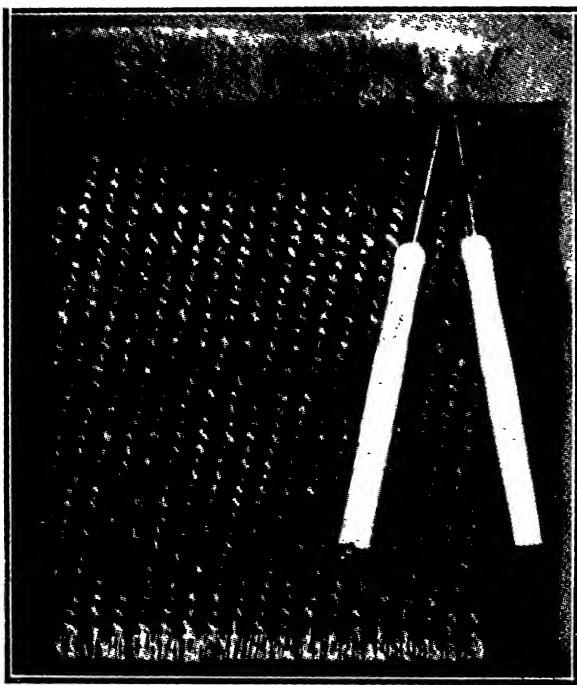
Fig. 23
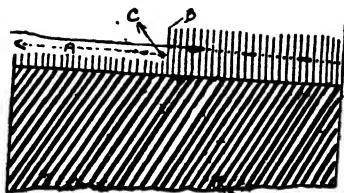
FIG. 24 A
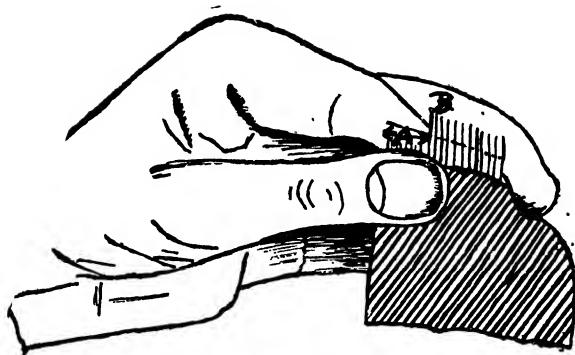
FIG. 24 B
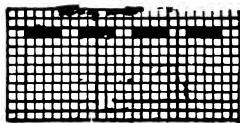
FIG. 24 C

manufacturer and the merchant. What manufacturer may measure, the merchant. may find. it different and · so the trouble and the friction between different classes of businessmen arises.

Federal Specification Board, America, have fixed up a standard for widths and lengths as follows :—

"The width and other dimensions shall be determined by laying the material on a flat surface without tension, then measuring the distance prependicular to the length between the selvedges to an accuracy of 1/16 inch. These measurements shall be taken in different places in the sample and the results averaged."

. When measuring the width of a piece of cloth it should be opened in the middle, the creases straightened out carefully and then measured by measuring tape. The cloth should be measured at several places. The heavier type of fabrics such as twills, Drills, Jeans, etc. measure well but the lighter type such as mulmull, Jacconets, muslins, lenos, voiles, mosquito netting. cloth, etc., must be measured with common sense as well as with measuring tape, on account of these fabrics being very elastic.

SHRINKAGE TESTS

(a) Shrinkage of warp and weft:—

During the actual process of weaving, the warp and weft yarns are perfectly straight, but when the two yarns are combined to form cloth, curvature is developed on the yarns according to the interlacings of the design. When the cloth is subjected to the finishing processes, more contraction in width and length is. noted and.

shrinkage˙ is developed among the fibres, thus further increasing the curvature. Consequently, if threads and picks taken from a finished sample of cloth are drawn straight and measured, the result will indicate the warp length and reed width necessary to produce that particular size of finished cloth.

· The contraction can be ·ascertained by taking a number of threads and picks and measuring the length as accurately as possible when these are stretched to their extreme length on a flat measure. Care must be taken not to draw out the fibres, especially when dealing with soft spun worsted or woollen yarns. An addition of 2 per cent. is some times made to compensate for " fibres shrinkage," but the expert analyst will draw on his experience and modify his results according to the particular type of structure under consideration.

Three inches of warp draws out to $3\frac{3}{8}$ inches.

Three inches of weft draws out to $3\frac{3}{8}$ inches.

(*b*) Shrinkage of Finished fabrics :—

Tests are made as·a rule to determine the shrinkage of a cloth either in finishing or in washing. In both cases, the test is made by measuring, before and after shrinkage, the warp and weft way dimensions of a square, marked on the cloth. If the·test is to indicate the shrinkage in finishing, the cloth must be treated in a way which will imitate as closely as possible, the finishing which the cloth will be given. If the test is to indicate shrinkage in washing, the cloth should be boiled for one hour in one per cent. soap solution. In the case of coloured goods, this test, should be carried out at the highest temperature which the colours will stand.

WEARING TESTS

Many attempts have been made to devise tests for measuring the resistance of a fabric to wear. Machines have been made in which the cloth is subjected to friction from revolving knives, by rubbing over abrasive blocks and by rubbing against itself.

The machine illustrated in Fig 25 is found most useful in deciding which of any two or three cloths has the best wearing qualities. Although the tensile-strength test is a criterion of the quality of materials used, this does not by any means denote that the strongest cloth offers the most resistance to wear. This may be caused by laundering, rubbing against other cloths or hard materials, friction due to internal stresses or other causes. To use the machine, the sample should be prepared as for strength testing, that is cut or torn wider than required and frayed down each side until a width of 2 in. is obtained on cloths up to 10 ozs. per squared yard or to 1 inch wide on heavier fabrics. The samples should be fixed perfectly straight in the grips, and the tension weights removed whilst doing so. The upper grip is mounted on a traverse bar to which a to-and-fro movement is imparted, so that the cloth is worn or rubbed over an area of $\frac{3}{8}$ in. wide; whilst an internal movement between warp and weft threads is set up, which breaks any binding effect due to finishing, and is a feature of practical wearing conditions. On any of the samples being rubbed through, the pendulum falls and operates an electrical push-pull switch, so that on the third sample breaking, the machine automatically stops. A counter is provided for each sample, and these

can be instantly reset to zero and are put out of action as the pendulums fall inwards.

The machine should be run at 100 strokes per minute, and the length of stroke (which is adjustable) be set at 4 ins. Two sets of tension weights are provided, the lighter one for fabrics not exceeding 10 ozs. per square yard, whilst the pressure of the rubber on the sample is 1·75 lbs. Ten tests of each sample should be taken, and the results averaged.

With some materials that give off a lot of fluff, it is sometimes advisable to stop the machine and give the "rubbers" a brush with an ordinary clothes brush, to prevent this .fluff getting between "rubber" and sample, and setting up a rolling action preventing proper contact between these two.

In addition to these mechanical tests on cloth, many chemical tests have to be made, and also there are many tests which have been devised for special fabrics.

Of the former tests the most common are those for the estimation of size, acidity and the various tests for the detection and estimation of overbleaching.

COMMON FAULTS IN CLOTH

The common faults found in woven fabrics are :—

(a) BAD SELVEDGES :—These should be avoided by the manufacturers as they cause much trouble to the finisher and are not liked by the customer and consumer.

(b) BROKEN ENDS IN CLOTH :—Due to carelessness of the weaver. As soon as the warp thread breaks on the loom it should be pieced up.
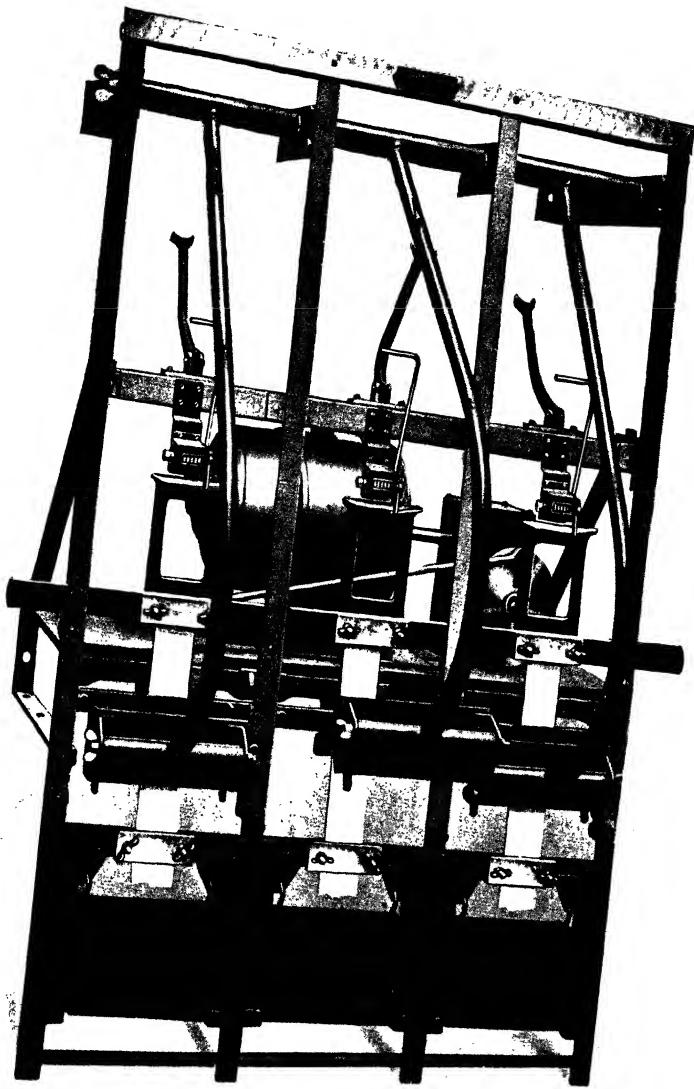
FIG. 25

Cloth Wear Testing Machine

(*c*) REED MARKS :—It gives bad appearance to the cloth and these marks should be avoided by the manufacturer.

(*d*) BROKEN PICKS :—Due to bad 'picking'. These should be avoided by the weaver.

(*e*) THIN PLACES :—Usually seen in weft, caused by careless weaving.

(*f*) THICK PLACES :—Too many picks together, caused by careless weaving. Reed may be beating too hard against fell of the cloth and thus forcing more picks per inch than necessary.

(*g*) MIXED WEFT :—Caused by weaver using the wrong kind of weft for Picking.

(*h*) TEMPLE MARKS :—These are in the form of small holes on the cloth. If the temples do not work easily as the cloth is being drawn round the cloth roller there is a dragging action and the temple pins tear the yarn.

(*i*) UNEVEN WARP & WEFT YARN :—Due to careless spinning of warp and weft. These uneven places in warp and weft show up very badly in the finished fabric.

(*j*) STAINS :—

    (*a*) OIL STAINS :—Received from spinning, weaving or finishing machinery.

    (*b*) IRON STAINS :—Usually caused in grey cloth by the reed of the loom becoming rusty through standing sometime, so that when the yarn passes through, it gets stained for few inches. These stains appear in grey goods right across

the piece. These stains are also caused in Bleaching and Finishing, and can be removed by rubbing with oxalic acid.

(c) MILDEW STAINS :—Appear after the goods have been finished for some time. Grey and sized goods are more liable to mildew than bleached goods. When the cloth is badly attacked by mildew, the yarn is tendered and uncurable. The best thing is to use antiseptics such as Zinc chloride in the size, used for sizing yarn before weaving.

SECTION II

. Analysis and testing of knitted fabrics

In the analysis of knitted fabrics the undermentioned points must be given detailed consideration :—

1. The character of the stitch employed.
2. Quality of fabric.
3. Kind of yarn (or yarns) used, count, direction and extent of twist, nature of constituent fibres, colour.
4. Type of machine used for knitting the fabric.
5. Machine gauge.

In the case of fancy fabrics full particulars of the design must also be obtained, and when fabric is in garment form the method of seaming and making-up should be noted, also whether the garment is fully fashioned, "seamless" or cut.

Structurally, looped fabrics can be divided into two broad classes, viz.:—

(a) Weft knitted   (b) Warp knitted

The four principal stitches in each class are :—

(1) Plain   (3) Tuck
(2) Purl   (4) Fleecy

(a) Weft Knitted Fabrics, are composed wholly of plain stitches, show the inclined portions of loops on the face side and the curved (semi-circular) components at the back. These plain fabrics can be unroved from either end and require only a single set of needles for their production. Fabrics containing purl stitches, on the other hand, need either double-headed needles or two separate sets of needles to produce them. When some wales are composed of a succession of purl stitches and the remaining wales of a succession of plain stitches, rib fabric is made. This fabric is characterised by its lateral elasticity and can be unroved from the end that was knitted last, but not from the other end. Purl fabric, so-called, has certain courses made up of plain stitches and the remaining courses made up of purl stitches. Its special feature is its elasticity in the direction of its length, and like plain fabric, it can be unroved from either end.

Tuck Stitches are formed behind plain or purl stitches if the latter are not cleared when needles receive new loops. In fabrics containing tuck and plain stitches, if tuck loops are made together in two or more adjoining wales, long loose loops float at the back of the fabric. Fleecy stitches are interlocked in fabric without being actually knitted-in, and can be withdrawn without breaking up the structure of the fabric.

(b) Warp knitted Fabrics, even when composed wholly of plain stitches, cannot be unroved from either end. In analysing the structure of these fabrics it is necessary to ascertain not only the character of the stitch employed, but also the manner in which the warp

threads are traversed. "Atlas" and "Milanese," for example, are both double-bar warp fabrics made up of plain stitches, and only differ in so far as the traverse of the threads is concerned. In "Milanese" each thread traverses right from one side of the fabric to the other before returning, whereas in "Atlas" traverse is limited to a predetermined number of wales. These two ladder-proof fabrics are distinguishable one from the other by reason of the fact that in "Atlas" the courses at which the threads reverse direction appear somewhat different from the others. When warp threads of various colours are used the traverse of each set of threads can be followed fairly easily with naked eye, but the aid of a magnifying glass or low-power microscope is almost essential in the analysis of self-colour warp fabrics. The traverse of each set of threads is registered on point paper.

2. QUALITY OF FABRIC

The term "quality" is used in connection with knitted fabrics in reference to their relative slackness or stiffness. A good quality fabric is one which is neither too boardy nor too slack. The most convenient method of measuring quality is by counting courses per inch. A one-inch glass is useful for this purpose when dealing with fine-gauge fabrics.

3. KIND OF YARN USED

As all weft knitted fabrics can be unroved from the end that was knitted last there is little difficulty in obtaining sufficient lengths of yarn to make the requisite tests for count, twist, etc. In cases where after-treatment of the fabric has affected the count of the yarn, the

17

necessary allowance must be made for the loss incurred. The testing of yarns used in warp knitted fabric is less easy because it is practically impossible to withdraw any reasonable lengths from the piece. The short lengths obtainable must be carefully measured, weighed on a very delicate chemical balance and the counts found by calculation. A yarn assorting balance will give approximate counts.

4. TYPE OF MACHINE

The character of the stitch employed is the first indication of the type of machine used for knitting the fabric. Selvedged weft knitted fabric, whether it is fashioned or straight, is made either on a straight bar bearded needle machine or on a flat knitting machine, probably on the former if it is plain fabric and on the latter if it is rib or purl.

Tubular fabric or fabric with cut edges, is most likely knitted on circular machines with multiple feeders. Examination of the fabric under a magnifying glass will often disclose a relatively slack or tight course recurring at regular intervals even when the stitch length appears to the naked eye to be perfectly even. The frequency with which the slack or tight course recurs, measured in courses, gives the number of feeders knitting concurrently. Should this method fail, however, provided the fabric is available in tubular form as knitted, the number of feeders the machine, (on which it was made,) possessed can be found by unroving. One circuit of loops can be unroved but further unroving of the loops, made from the same thread, is then arrested until the intervening courses, made from separate

threads, have also been unroved. By unroving until the first thread is released and counting the courses, the number of feeders is found. The number of needles in the machine or, in the case of straight bar and flat machines, the number of needles knitting is ascertained by counting the number of wales in the fabric.

5. MACHINE GAUGE

The gauge of machine on which fabric is knitted can be estimated only very approximately because every different gauge can accomodate a fairly wide range of yarn counts. To suit the particular needs of a manufacturer it may sometimes happen that of two machines of a similar type the one which has the more needles per inch knits up the coarser count of yarn.

Under average conditions the number of needles per inch is about two-thirds the number of wales per inch in the case of plain fabric knitted on latch needle machines, and about five-sixths the number of wales per inch in the case of plain fabric knitted on straight bar bearded needle machines. A plain tubular fabric with 24 wales per inch is probably knitted on a 16 N latch needle circular machine, while a plain selvedged fabric having the same number of wales per inch may have been knitted on a 30 G straight bar machine of the Cotton's type (30 G=30 leads in 3 inches=60 needles in 3 inches=20 needles per inch).

Strength Tests of Fabrics

These tests can be divided into two divisons :—
  (*a*) Bursting tests.
  (*b*) Breaking tests.

Bursting tests :—These tests are mostly applied for testing the strength of the knitted fabrics and are seldom applied to woven cloth. In essential these tests are made by subjecting a standard area of the cloth to gradually increasing pressure. till the fabric bursts. The results depend on the area over which the pressure is applied and so this must be kept constant.

In the machine designed by Rehse, Boult, Wooley and Olivier the pressure is applied by means of a piston. The last named machine is a device which can be fitted to any ordinary lea tester.

In Marten's machine the pressure is obtained by compressing air in a cylinder fitted with a rubber diaphragm over whch the cloth is stretched. The Jumbo Mullen Machine is similar, but the pressure is obtained hydraulically.

(b) *Breaking strain tests* :—The most widely used machine for Breaking tests is one made by Goodbrands. It is a constant traverse machine working on the weighted lever principle.

The preparation of the strips of cloth for these tests is important. The results vary with the width and to a lesser extent with the length of the strip. Also the result depends on whether the strip has been cut from the cloth warp way or weftway.

To avoid damage to the threads, the strips should always be cut from the cloth rather wider than necessary and the length way threads be then stripped out till the required width is obtained.

Both warp and weft way tests should be made and the direction should be stated. It is necessary to place the strips squarely in the jaws of the clamps as otherwise tensioning of the threads will be obtained.

Sometimes the strips are cut diagonally accross the cloth. Breakage of such strips is said to give a measure of the forces binding the threads together in the cloth.

Before carrying out any tests the following points should be carefully noted.

(1) That all the samples for test are in the same condition as regards moisture since dampness to a certain point increases the strength.

(2) That the speed in working the machine should be uniform.

(3) That the sample must be cut very accurately and to one size and placed on the machine so that the jaws grip evenly.

There are two methods of testing fabrics for breaking strength, one known as the ' *Grab* ' *test* and the other the
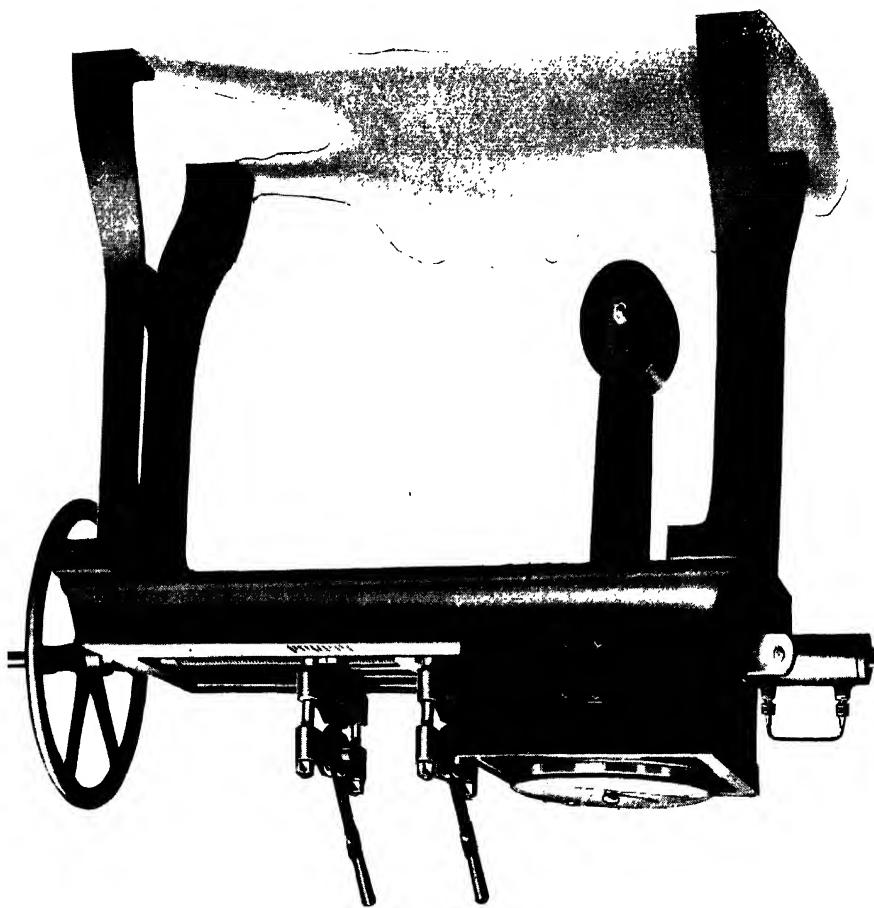
'*Strip*' *test.* . The former is used for heavy fabrics such as hose-pipe cloth; tyres,· sheetings; duck-cloth, canvas cloth, etc., whereas the latter is used for lighter fabrics such as ordinary woven fabrics, shirtings, Dhoti cloth, Damask, Drill, Twill and· other plain and Fancy fabrics.

In Grab test the· jaws of the testing machine are arranged to· grip the cloth at a set distance usually 1 inch. In strip test the cloth is cut a little larger than the stated size and the threads withdrawn each way till correct size is obtained. Strip method gives better results with lighter fabrics and is widely used.

HORIZONTAL CLOTH TESTING MACHINE

Fig. 26 shows a type of machine worked by hand.

This machine is made in three sizes to test 400, 700, and 1000 lbs. as a maximum break and is suitable for testing ·samples of 7 in. long· between grips and allows upto 6 in. for stretch, whilst samples, upto 7 in. wide can be tested.

METHOD OF TEST

To test the cloth, the test piece is placed and clamped between the two jaws and fully straightened out.

· If ·it is. tight on one side, it will tear instead of breaking all across almost instantaneously. When properly clamped the machine is set in motion by turning the handle. · The screw shows the near jaw away from· the fixed jaw and at the same time the weight is raised, the

pointer on the dial travels to show the strain. Immediately the cloth breaks the pointer remains stationary. The B. S. in lbs. is given on the dial and stretch in inches on the Scale.

Figure 27 shows a cloth Testing machine (Horizontal type) for testing heavy canvas, sail cloth and similar materials. The size of sample used is 7″ between the grips and upto 7″ or 9″ wide. The range of maximum test is from 400 up to 2000 lbs.

The weight is carried under centre of machine and works in the opposite direction to the ligther types. The levers carrying weight are of double steel forgings and attached to a roller working in Hoffman Ball Races. In place of the usual rack and catches, an oil plunge pump is fitted with piston attached to back grip, and the breakage of material under test allows finger on dial to come slowly back to zero. The machine can be fitted with rack and catches, these being placed under bed of machine, and a lowering motion attached to the same. The dial is fitted with a maximum indicating finger in addition to the ordinary one, and the travelling grip has an instantaneous re-setting motion. The motor is bolted to front standard and direct coupled through worm reducing gear with ball thrust-washers.

VERTICAL TYPE OF TENSILE TESTING MACHINES. (SCHOPPER TYPE)

The Machine, Fig. 28, is· specially designed to suit the requirements of customers who prefer the Continental type of machine for making a vertical test,
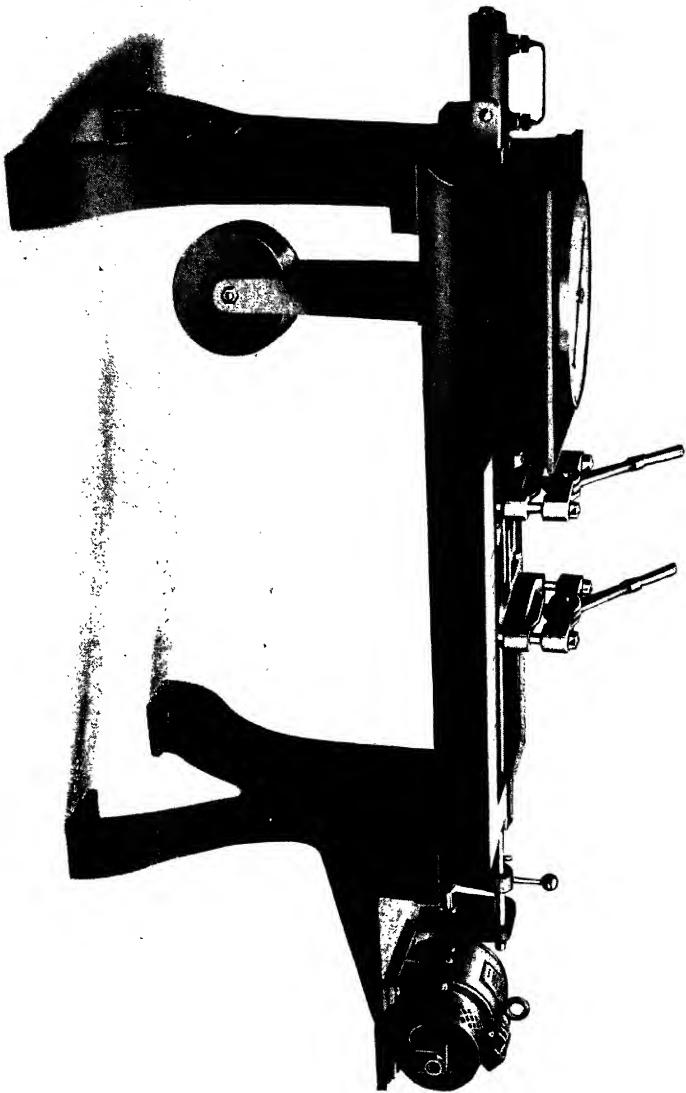
FIG. 27

Horizontal Cloth Testing Machine for testing heavy canvas, sail cloth etc.

It is designed to test samples of material up to 4 in. wide, and from 4 in. to 16 in. in length, with 25 per cent allowance for elongation or stretch. It can be arranged to indicate any desired breaking strain up to a maximum of 1,500 lbs., and can be graduated in either English or matric weights, or both. On machines with a higher maximum than 1,000 lbs., a geared lowering device, is attached to weight lever, allowing this to be easily lowered to zero position on dial plate. The stretch of the material at breaking point is shown on an engraved scale. The actuating roller works in ball bearings, and the indications on dial plate are marked off from actual weights suspended from upper grip. This grip is attached to actuating roller by flexible flat steel tape, and the pulling strain throughout being in direct vertical line, an absolute accuracy is assured.

The machine is fitted with two racks, with five catches operating on each, and the weight lever (which also acts as indicator) remaining stationary, after each test, until released.

Fig. 29 is another type of cloth testing machine (vertical type) and is arranged to test narrow samples up to 3 in. wide and 7 in. to 9 in. long between grips. This is made to test up to 100, 200, 300 and 500 lbs.
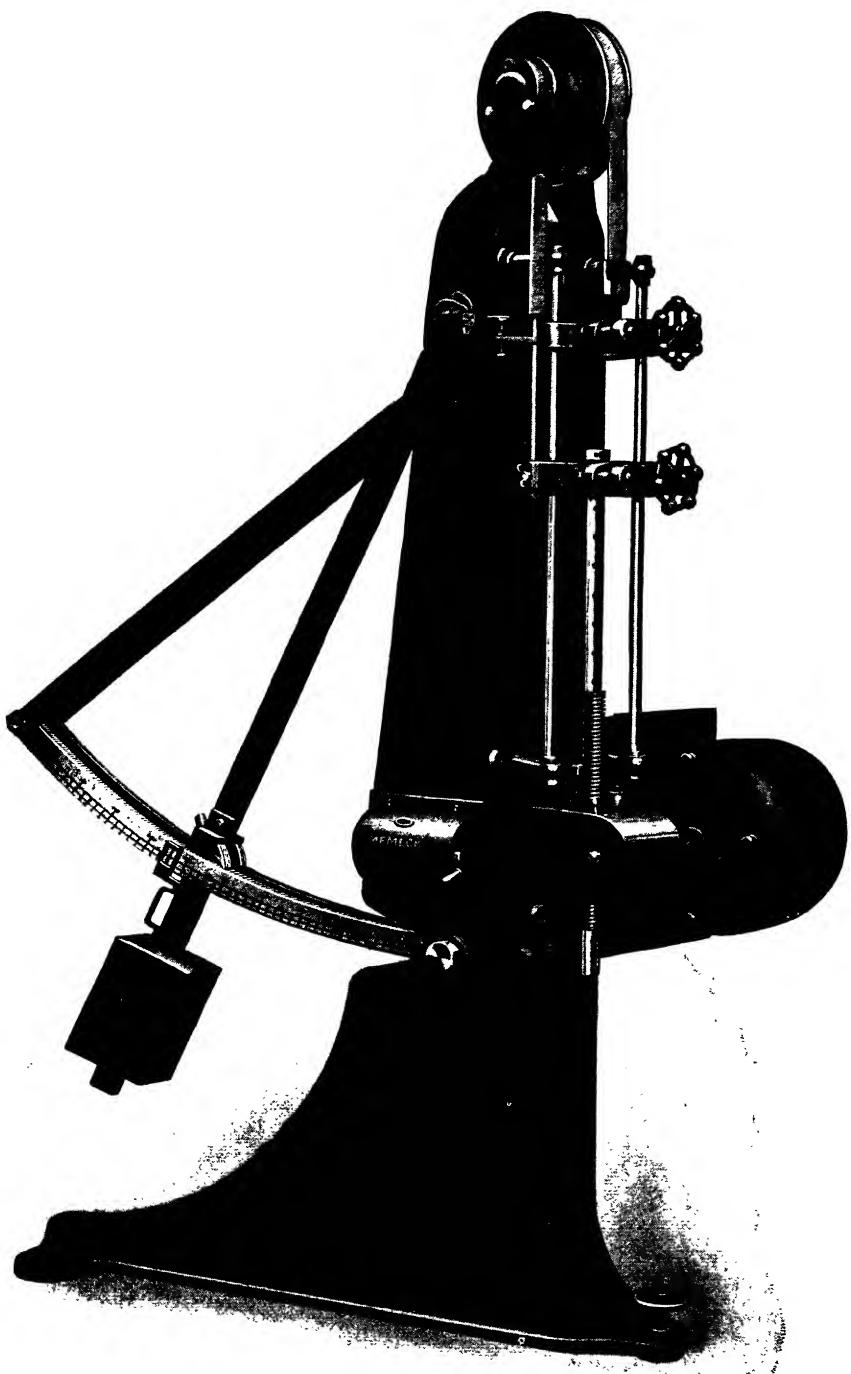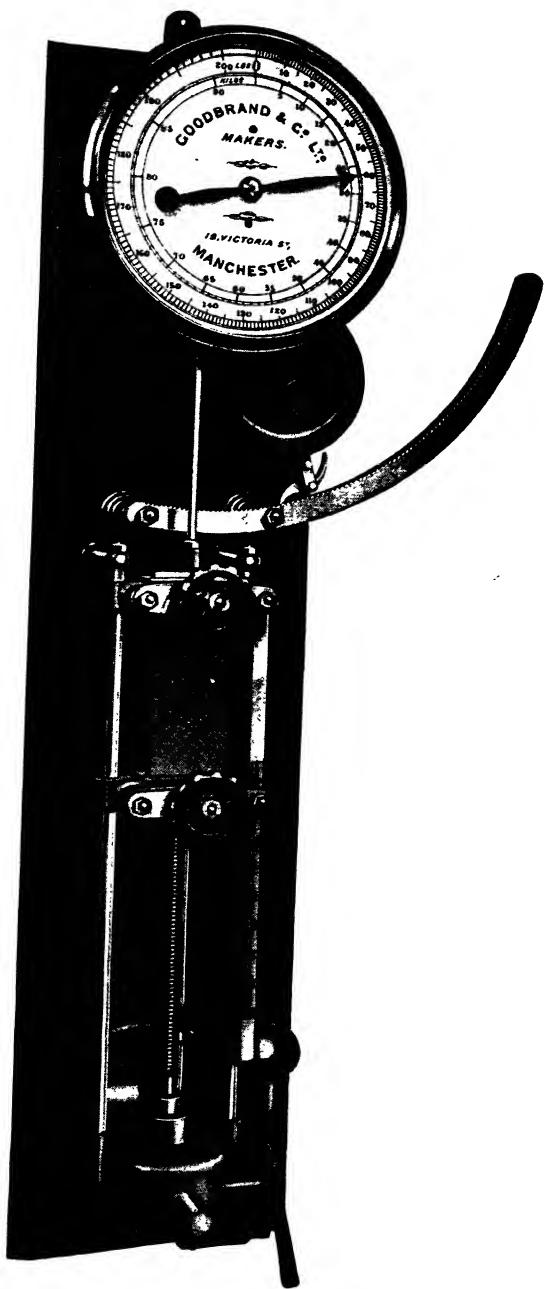
Fig. 29

Chapter V

Determination of Dressing and Finishing Materials in Textile Fabrics

Chapter V

Determination of Dressing and Finishing Materials in Textile Fabrics

Textiles are dressed up as a rule at two distinct stages of manufacture. The first is known as sizing and is a very important operation in Textile manufacture. Yarn as received by the manufacturer has a rough hairy appearance caused by passing through the different processes of spinning. In this state it is weak enough to stand the friction it would undergo on the loom during the pocess of weaving. The chief purpose of sizing is to strengthen the yarn and improve its smoothness without reducing its elasticity, pliability, cleanliness and colour. Size shields the yarn from the friction of the healds, reeds and take up motion of the loom. The Second Stage at which Textiles are dressed up is after they have been woven. The function of finishing is to increase the value of the cloth by modifying its important physical properties such as colour, lustre, stiffness or softness and thus fit it for the purpose for which it was designed. Many ingredients are used during this operation and each has its own effect on the fabric.

The following ingredients are used in Dressings and Finishing :

(i) Adhesive Substances :—The chief of these are:— Various starchy substances—wheaten flour, wheaten starch, sago flour, rice flour, tapioca flour, and farina (potato starch). More or less altered starches—corn starches, soluble starches, gloy, and dextrine. Gums— gum arabic, gum tragacanth, "gum tragasol." Various seaweed preparations—Irish moss.

Starches from various plants exhibit different sizing properties. They behave differently in boiling, in adhesive properties, and in stability of the viscosity during storage. Cooked starch pastes of maize are the most and of farina the least stable.

Wheaten Flour is the only one of the starchy subs- tances in general use which contains appreciable quantities of substances other than starch itself. It contains up to 15 or even 20 per cent. of gluten, the quantity and the quality of the gluten varying very much in different samples. It is the presence of gluten which renders wheaten flour more liable to mildew than other starchy materials. Mildew requires for its growth nitrogen, which it obtains with difficulty from the nitrogen of the air but very readily from proteins and other nitrogenous or- ganic substances. Gluten has, however, other properties which render its presence valuable for certain classes of sizing. It is a tough, elastic substance, having freat bind- ing and carrying power for such materials as china clay. Wheaten flour, if prepared properly, that is, steeped suffi- ciently, will give a full, supple feel to the yarn and will weave well, but insufficient steeping makes it harsh and very rough on the healds. It is not very white and darkens the yarn considerably.

Rice Flour :—The starch granules of rice are very small and hard, and are difficult to burst by boiling in the ordinary way. It is not much employed in sizing, but is occasionally used, mixed with six to ten parts of wheaten flour, to give a particular granular feel. In this case it should be steeped along with the flour, or preferably boiled, alone or with the China clay, before adding to the flour.

Maize Flour :—Gives a very thick, strong paste when boiled, but, like rice, requires much boiling to burst the starch granules. It is not much used in its unaltered state, but when made into the various grades of corn starch, finds considerable application in sizing.

Farina (Potato Starch) :—Gives a very thick paste on boiling, but has the great disadvantage that the paste rapidly liquefies when allowed to stand, or on prolonged heating. This tendency may be partially counteracted by the addition of a small proportion of caustic soda.

Farina is very white and is much used on this account in spite of the above mentioned drawback. It is sometimes used alone for pure sizing, but is much better mixed with other starches which give more permanent pastes, such as sago, wheat starch, or corn starch.

Sago Flour :—Produces a paste which has strong binding properties, and one which has little tendency to liquefy on prolonged heating. It dries to a tough, elastic film, and at the same time penetrates well between the fibres composing the yarn. It gives flexibility with strength and, for the counts and heavy reeds, is unsurpas sed. In practice it is usually mixed with 25 to 35 per

cent. of its weight of farina, the latter laying down surface fibres whilst the sago penetrates and binds. Sago requires considerable boiling to effect complete gelatinisation, four to five hours being none too long. In the presence of 1/4 to 1/2 per cent. of caustic soda, however, the process is very much shortened and a better size is obtained.

TOPIOCA FLOUR :—Is very variable in quality and, like farina, rapidly liquefies on prolonged heating, or even on standing for any length of time in the cold. It is not to be recommended for any class of sizing.

WHEAT STARCH :—Is a pure, practically white starch, made from wheaten flour by removal of the gluten and other impurities. It produces a fairly strong paste with good keeping properties. It can be used either for pure size or to replace fermented flour, which itself consists of almost pure wheat starch, in mixings containing china clay.

SOLUBLE STARCHES :—These are starches altered by heat treatment or by digestion with dilute acids or malt extracts. There are many brands of soluble starches in the market, most of which give satisfactory results when used according to the manufacturers' directions. They usually gelatinise on heating more readily than natural starches, and give a penetrating, soft-feeling size.

DEXTRINE :—Is a variety of soluble starch, the alteration treatment having been carried a stage further than " soluble starch ". It is little used in sizing on account of its sticky nature, but it can be used with good results

if mixed with starch, as it possesses considerable binding power.

GLOY:—Is another of the alteration products of starch, and is obtained as a stiff jelly. It penetrates well and gives a soft feel to the yarn, the amount of emollient substances required in the size being reduced by its use. It is rarely or never used alone but in combination with ordinary starches.

GUMS :—Natural gums, gum tragacanth, gum arabic etc., are not to be recommended for regular use in sizing, as, although they are strong adhesives, they require great care in their use, as they are not easy to dissolve to a homogeneous solution. Also they are very liable to develop mildew.

" Gum Tragasol " is unlike the other gums mentioned, being far more a manufactured product. Unlike them, it does not tend readily to develop mildew. It binds well and gives considerable suppleness to the yarn, and is quite suitable for all classes of sizing.

(ii) EMOLLIENTS OR SOFTENERS :—These are used to give suppleness, and also to provide " lubrication " for the yarn. Suppleness, is given by fats and fatty oils, such as tallow, palm oil, castor oil, olive oil, cotton-seed oil, etc., and also glycerine. Substances used to give a smooth, polished surface to the yarn include various soaps and waxes and wax-like fats, such as paraffin wax, beeswax, Japan wax, and spermaceti.

According to recent work by the Shirley Institute, Manchester it appeares that reductions or even the

19

elimination of fat in pure sizing would not be attended by any interference with loom efficiency. Also, in this particular case, by exercising careful control in sizing and reducing the average amount from 16 to 12 per cent., considerable improvement in weaving and in costs resulted.

TALLOW :—is the most widely used of all softeners, and its use in heavy sizing is almost universal. For the latter class of goods it is certainly as good and probably better than any other softener, but for light sizing it can be replaced with advantage by much smaller quantities of soap.

Tallow for use in sizing should be white and firm and should have a high melting point. Old tallow becomes yellow and rancid and may contain high percentages of free fatty acid. The quantity of the latter is usually a fair indication of the age of tallow and of its suitability for storing. Tallow is preferably bought during the winter months, and not later than March, in sufficient quantity to last through the summer. It should be stored in a cool place.

Very white tallow should be regarded with suspicion until it has been tested chemically. A simple test with a drop of methyl-orange will often indicate the presence of the mineral acid which has been used to bleach it.

CASTOR OIL :—is not suitable for use alone as a softener, but, when mixed with other fats or soaps can be used with good results and gives a feel peculiarly its own.

OTHER FATTY OILS :—Olive oil, palm oil, cocoanut oil, cotton-seed oil, etc., are not used to any great extent, but there is no objection to their use provided they are obtained in a satisfactory state of purity. Colour and clarity are good indications of suitability, but a proper chemical analysis is always advisable before a new softener is put into regular use.

GLYCERINE :—Is not as well known as a sizing material as it deserves to be. It is a powerful deliquescent as well as emollient, and has mild antiseptic properties. Used in " clay mixing " for moderate weight, it can take the place of both tallow and magnesium chloride. But if it is substituted for magnesium chloride it gives a different feel to the cloth. It gives most satisfactory results if used with tallow or other softener. In pure size it gives great suppleness, and, by its deliquescent properties, prevents any tendency of the adhesives to become harsh or brittle.

MINERAL OILS :—These should be absolutely avoided.

PARAFFIN WAX :—Is very strongly to be condemned as a sizing material particularly for goods intended for either bleaching or dyeing. It is not attacked by any of the usual scouring agents, and is extremely difficult to remove completely from the cloth. In addition to this, it does not emulsify at all readily, and is often to be found floating in a thick layer on the top of the size in the sow box, whence, if it gets on to the yarn at all, it does so in patches. The peculiar feel, which is the strongest reason put forward

for its use, can easily be imitated with a mixture of Japan wax and spermaceti, which, although higher in price, will be found to be more economical in the long run.

SPERMACETI :—is a glistening white, wax-like substance, which is more brittle than paraffin wax. It is not a true wax, but is similar in composition to the fats. It can be removed from the cloth by scouring with alkali, just as the fats can. It gives a very fine, smooth feel to yarn, and is an excellent antidote to chafing. It is best used mixed with Japan wax, the mixture being less brittle than spermaceti alone.

JAPAN WAX :—is yellowish in colour, and is fairly hard and brittle. It is similar in composition to spermaceti, and is an excellent sizing material, either alone or mixed with spermaceti, for yarns which are liable to receive much rubbing on the loom.

BEESWAX:—consists largely of unsaponifiable substance and, apart from its scarcity and high price and the dark colour of the commercial varieties, is not a suitable material for use in sizing.

SOAPS :—For pure size, soaps are very efficient softeners, being greatly superior to tallow. They cannot be used along with either zinc chloride or magnesium chloride, as these substances react with soap to give insoluble compounds, having practically no value as softeners. Hence the use of soap in China clay mixing is almost unknown, and rightly so.

Some soaps have the objectionable property of causing excessive frothing in the sow-box, and are often con-

demned on this account. Castor oil soap does not possess
this defect to a great extent, and is probably the best of
all sizing soaps. If any difficulty is experienced in obtain-
ing it in a known degree of purity, it can easily be made
as required by dissolving $1\frac{1}{5}$ lb. of solid caustic soda
or its equivalent in caustic soda liquor, in about a gallon
of water, stirring in 10 lb. of castor oil and then whilst
still stirring, blowing in steam for a few minutes. If now
stood aside for a day, with an occasional stir, a semi-
liquid soap is obtained containing a known amount of
solid matter (real soap), which is more easily incorporated
with the other ingredients of the size than is ordinary
solid soap.

PATENT SOFTENERS :—Recently a great number of
tallow substitutes have been put on the market. The
great bulk of these are nothing but soap, mixed with
large quantities of water. A large number of these have
been analysed at various times, and the smallest percent-
age of water found was 50, and the greatest 90. Since
soap is a better softener than tallow for pure size, these
substitutes usually do most of what is claimed for them.
The price is always lower than that of tallow, but is often
about five times the real value. There is no reason why
the manufacturer should not make his own sizing soap
as he requires it, at cost price. In any case he should
look with suspicions on "patent" softeners until he
knows their composition.

(iii) DELIQUESCENTS :—Substances which readily ab-
sorb moisture are used to prevent the starchy adhesives
from becoming too dry and brittle, and to counteract
the drying action which always results from the actual

working processes. The ideal aimed at is to maintain the percentage of moisture in the sized yarn at, as nearly as possible, the moisture content of the natural cotton, *i.e.*, 8 to 9 per cent.

The deliquescents in general use are magnesium chloride, calcium chloride, and glycerine. Zinc chloride is also strongly deliquescent up to a point, but is used in sizing, not on account of this property, but as an antiseptic. It is not so good as the other deliquescents mentioned, and is very much higher priced.

MAGNESIUM CHLORIDE :—Is obtained either as a solid crystalline mass or as a concentrated solution. For use it is conveniently dissolved in, or diluted with, water until its density is 54° Tw., the solution then containing $8\frac{1}{2}$ lb. of solid magnesium chloride per gallon.

Magnesium chloride is strongly deliquescent in an ordinary weaving-shed atmosphere, but is very subject to changes in atmospheric humidity, readily losing most of its water in a dry air. It requires using with discretion, because when heated to comparatively low temperatures, it partially decomposes to give hydrochloric acid. This may occur on overheated cylinders in a slasher machine, and give rise to tender warps. It follows obviously that it must on no account be used for cloth, which has later to be singed or calendered.

The common name for magnesium chloride in Lancashire is " Anti " meaning " antiseptic. " It is not antiseptic in the slightest degree, and in fact, on account of its moisture-absorbing properties, encourages rather than prevents mildew. It should never be used except

in conjunction with some real antiseptic.

CALCIUM CHLORIDE:—Is very similar to magnesium chloride in general properties, but is cheaper than the latter, though it is more liable to contamination with iron. It gives worse weaving and causes more damage to the healds than magnesium chloride, which probably accounts for the prejudice against its use.

GLYCERINE:—Is a more satisfactory deliquescent than either of the above, being less sensitive to changes in the humidity of the atmosphere. There is no danger attending its use for any class of goods such as there is with magnesium chloride.

(iv) WEIGHT-GIVING SUBSTANCES:—China clay is in a class by itself. Other insoluble substances are French chalk and Barium sulphate. A few soluble salts are also used, chiefly Epsom salts, magnesium chloride, and zinc chloride. The two latter have special functions other than that of giving weight, but are often used in some excess for this purpose.

CHINA CLAY:—Is superior to any other weighting material, for various reasons. It has an unctuous feel, which it retains on the yarn, and consequently has no cutting action on the healds, and no tendency to give a stiff, boardy feel to the cloth. It is very bulky, and so gives a full appearance for a given weight, though on this account there is a limit to the weight of size which can be put on with china clay alone as weighting material.

A good clay should be white, and at the same time free from artificial whitening matter (blues). It should

have a full, greasy feel, and should readily form a creamy paste with water. It should be free from grit, and should contain no iron, or free acid.

EPSOM SALT:—Gives weight without bulk. It also tends to stiffen the cloth and, if used in excess, particularly in conjunction with much magnesium chloride, may crystallise in the warp or in the cloth, and tender the same to a disastrous extent. If a firm feel is desired without the use of metallic chlorides in the size, Epson salt in valuable, though it is used more for finishing cloth than for sizing yarn.

BARIUM SULPHATE :—May be obtained in two forms. The mineral "heavy spar" is quite unsuitable for sizing, being too granular and harsh feeling. The precipitated variety, especially if freshly precipitated, is more suitable, but it has never come into general use. It is poisonous and too rough on the healds.

FRENCH CHALK :—Is supposed by some to possess special virtues for sizing, but it is inferior to good china clay, and is higher in price. It will not mix easily.

Magnesium chloride and zinc chloride, though used specifically for very different purposes, both add considerable weight to the yarn.

(v) ANTISEPTICS:—Some kind of antiseptic substance is absolutely necessary in all sizes containing · deliquescents, as moist starch is a very suitable medium for the growth of fungi (mildews). Sizes containing any nitrogenous matter, *e.g.*, the gluten of wheaten flour require much more antiseptic than size made up with pure

starches. Whether a size contains deliquescents or not, it is advisable to use antiseptics in sufficient quantity to protect the cloth against unforeseen, but by no means unusual conditions.

The number of antiseptics which have been tried and used at various times is very large. The following are the principal ones :—

INORGANIC SUBSTANCES :—Zinc chloride, zinc sulphate, copper sulphate, sodium fluoride, sodium silico-fluoride, and boric acid.

ORGANIC SUBSTANCES :—Phenol (carbolic acid) and sodium phenate, cresylic acid, salicylic acid, and thymol. Glycerine is also a mild antiseptic.

Of all the many antiseptic substances suggested and tried, a few are at all commonly used,

ZINC CHLORIDE :—Is by far the most widely used antiseptic for heavy size. It is usually obtained in solution of density 120° Tw., containing for a good commercial product, say 43 or 44 per cent., approximately 6·5 lb. dry zinc chloride per gallon. It should be used in the proportion of 8 to 10 per cent. of the weight of the flour, solid zinc chloride ; that is, a minimum of 4 gals. solution to each sack of flour.

It darkens the colour of wheaten flour somewhat, and in this respect is objectionable. It is stated to have a thickening effect on the yarn, and thus to improve the appearance of the cloth. In strong solution it certainly has a mercerising action on cotton, but is doubtful whether this takes place at the low concentrations at which it is used in size.

20

Like magnesium chloride, zinc chloride decomposes to give hydro-chloric acid when heated, and so cannot be used for goods intended for finishing.

BORIC ACID:—is a stronger antiseptic than zinc chloride, and is largely used for pure size. It can, of course, be used equally well for heavy size. It forms a dry, white powder, readily soluble in water. It should be employed in the proportion of 3 to 4 per cent. on the weight of the starch.

SALICYLIC ACID:—is one of the most powerful antiseptics known,. and is very suitable for all classes of sizing. It may be obtained in B. P. and technical qualities, the prices being very little different, considering the relative strengths. The B. P. acid forms glistening white crystals, and is 100 per cent. salicylic acid. The technical variety is usually a pale brownish powder of about 75 per cent. strength. Salicylic acid should bet used in the proportion of $\frac{1}{2}$ to 1 per cent. on the weigh of starches. Being very slightly soluble in cold water, it should be dissolved in a pail of boiling water before adding to the size.

SODIUM SILICOFLUORIDE:—is sold under the name of "Salufer." It is a white powder, soluble in cold water, and is of the same strength—as an antiseptic—as boric acid.

TESTS FOR GLUTEN AND STARCH IN FLOURS:—Gluten and starch are the chief ingredients in flours. Thomson has made a comparative test of flour and his results are given as follows :—

		English Flour	Egyptian Flour
Starch	... ...	68·09	67·71
Gluten (dry) ...	...	9·88	2·36
Glucose	... ...	4·93	8·55
Dextrine	... ...	3·51	7·39
Bran etc.	... ...	Trace	Trace
Water	... ...	12·78	13·52
Ash	... ...	0·81	0·42
		100·00	100·00

The chief constituent of flour should be gluten and the larger the percentage of Gluten the better the flour for sizing and Finishing purposes.

QUALITATIVE TEST FOR GLUTEN :—A good quality of gluten should stretch for at least one inch before breaking. The gluten should be stretched and the distance it stretches should give its quality. The gluten that stretches most is the best for sizing purposes.

QUANTITATIVE TEST FOR GLUTEN :—Take about 1 *oz.* of flour and weigh accurately, then mix with water into a kind of dough. Place this in an open piece of cotton cloth and allow a stream of water to run over it and through it until all the starch has been washed out. This should leave nothing practically but gluten. This should then be dried and weighed. From this the percentage of gluten is then determined.

TEST FOR COLOUR OF FLOURS: —Take an equal quantity of both the sample and the standard. Mix each with an equal quantity of water, then boil sepa-

rately. After boiling place each in a test tube, allow to cool. If there is any difference in colour it will be visible.

TEST FOR CONSISTENCY OF FLOURS :—Take about 9 or 10 *oz.* of water and 1 *oz.* of flour, mix and boil for about 20 minutes, pour into a glass and allow to stand for 5 or 6 hours. Suspend a pointer above the mixture, liberate it suddenly and notice how far it penetrates into the cold-flour and water paste. Carry this on with several samples and the distances penetrated will give the various consistencies.

TEST FOR STARCH :—Boil a small piece of starch finished cloth in water, cool and to the filtrate add a solution of iodine solution and strong sulphuric acid. A beautiful indigo blue colouration indicates the presence of starch.

ESTIMATION OF SIZE IN COTTON AND LINEN CLOTH :— Weigh the cloth sample, wash in water, place in a weak solution of caustic soda and boil for 30-40 minutes. Remove sample and wash again in cold water. Boil again for 60 mins. in 1 per cent. solution of hydrochloric Acid adding water as it evaporates. Work well in cold water, dry slowly and then allow the sample to regain its natural moisture. Weigh and the difference will be the loss of sizing material. From this the percentage of sizing can be calculated. For wool, instead of caustic soda, hydrochloric acid is used for boiling.

ESTIMATION OF MOISTURE IN FINISHED FABRICS :— Weigh about 10 grams of the cloth in a weighing tube

and dry in the steam oven until the weight is constant. After drying for a few minutes cool and weigh the cloth in the weighing tube. Repeat it till the weight is constant. From the initial weight of the cloth and the weighing tube deduct the weight of dried cloth and the weighing tube and this will give the loss which is due to moisture. The percentage of moisture is then calculated.

ESTIMATION OF FATTY AND WAXY MATTER :—About 10 grams of the cloth is carefully weighed and the fatty matter dissolved and extracted completely by means of ether or petroleum in a Soxhlets' fat Extraction apparatus. After all the Fatty matter is dissolved in the solvents, the solution is heated on a water bath until the ether or petroleum is all driven off. After complete removal of the ether the residue is cooled and weighed. The percentage of fatty and waxy matter is then calculated.

ESTIMATION OF MINERAL MATTER SUCH AS CHINA CLAY, MAGNESIUM, CALCIUM, AND ZINC SALTS :—Weigh about 10 grams of the cloth and burn it in a weighed Platinum or porcelain crucible. When all the organic matter has been destroyed a grey white ash is left which is carefully weighed and the percentage of the mineral matter calculated. This weight will contain the weight of china clay and all those substances which are not volatilised. The percentage of inorganic salts present in the size should be estimated separately and these results when deducted from the total weight will give the weight of dry china clay in the size. If to the weight

of dry china clay 10 per cent. is added for water, the actual weight of natural china clay is obtained.

ESTIMATION OF STARCH IN CLOTH :—This is usually obtained by deducting the weight of fatty matter (including softners etc.) weight giving substance, such as, china clay etc., Deliquescents and antiseptics, gluten mineral substances and moisture from the total weight of the sizing material in the cloth..

ESTIMATION OF MAGNESSIUM AND ZINC CHLORIDES :—Magnessium chloride is changed to Magnessium Pyrophosphate by the addition of Ammonium phosphate and this in turn is oxidised to Magnessium Oxide which is weighed to a constant weight and the amount of Magnessium Chloride calculated from the following equations :—

$$2 \, (Mg \, Cl_2) \; \rightarrow \; Mg_2 \, P_2 \, O_5 \; \rightarrow \; 2 \, Mg \, O$$

$$\underbrace{}_{2 \times 95} \qquad \underbrace{}_{222} \qquad \underbrace{}_{80}$$

Magnessium
Pyro-phosphate
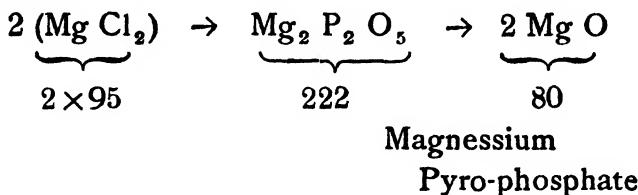
Zinc chloride is first reduced to Zinc Sulphide by treatment with sulphuretted hydrogen and this in turn is oxidized to Zinc Oxide and the amount of Zinc Chloride is calculated from the following equation :—

$$Zn \, Cl_2 \; \rightarrow \; Zn \, S \; \rightarrow \; Zn \, O$$

$$\underbrace{}_{136} \qquad \qquad \underbrace{}_{81}$$
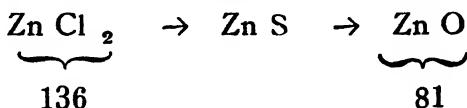
For a detailed method of estimation of Inorganic salts present in the size the reader is advised to refer to standard books on Inorganic Qualitative and Quantitative analysis,

Chapter VI

Testing of bleached & coloured fabrics

Section I—Testing of Bleached Fabrics.

Section II—Testing of Coloured Fabrics

SECTION I
Testing of Bleached fabrics

No problem in bleaching is so difficult to solve as the nature and cause of any particular damage or discolouration to the material.

The following are the principal mechanical and chemical damages that are so commonly associated with the bleached fabrics, and the ingenuity of the person engaged in the testing of these lies in tracing the cause of these damages and the method of preventing the same:—

(a) MECHANICAL DAMAGES in Bleached fabrics caused by Bleaching machinery. These may occur at any stage of the processes, such as, bowking, Kier Boiling, souring, chemicking, or washing. These can only be stopped by carefully over-hauling of the bleaching and washing machinery.

(b) MINERAL OIL STAINS, derived from lubricating oil used in machine. These may be removed by organic solvents such as Petrol or Benzene or milling with soap.

(c) LIME STAINS:—These may be produced by bad boiling or plaiting in Kiers. Deficient circulation of liquor in Kiers, too strong a liquor, incomplete souring of the goods. Such stains may also occur in soda boil for similar reasons.

(*d*) IRON STAINS:—Due to rust in kiers or other machines. These may also arise due to the presence of iron in water or chemicals used for bleaching. These are easily removed by rubbing the fabric with strong concentrated oxalic acid solution.

(*e*) LEAD STAINS:—Are similar in appearance to those caused by iron and are caused by contact with dirty lead pipes. They cannot be removed as a rule. Sometimes they will dissolve in very dilute nitric acid or solution of ammonium acetate.

(*f*) DISCOLOURATION & STAINS caused by incomplete bottoming in Bowking. These are very common. Any residual colouring matter left in the fibre after this process gradually re-appears on the surface producing loss of colour. Closely related to these discolouration are those produced by resin and other soaps. The process depends upon the liberation of the fatty or rosin soaps and then the subsequent removal of sodium salts by re-boiling and washing.

(*g*) TENDERNESS:—In the case of cotton fabrics this may be due to (i) oxycellulose produced in the lye boil or by over-bleaching or by the presence of chloramines, owing to the action of chemic or unremoved proteids (ii) Hydrocellulose produced generally by the presence of unremoved mineral acid.

Over bleaching may be caused by (*a*) using too con-
centrated a chemic, (*b*) leaving goods in chemic
too long or at an unsuitable temperature, (*c*) the
presence of particles of dust or metallic oxides
which act as oxygen carriers, (*d*) leaving goods
lying exposed to the air when saturated with
chemic.

Hydrocellulose is formed by leaving traces of mine-
ral acid in the cotton by incomplete washing.
A form of hydro-cellulose may be produced in
the kier by the prolonged action of caustic soda
on cotton at a high temperature. Goods con-
taining hydro-cellulose or oxy-cellulose go
brown and disintegrate gradually on storing
with loss of tensile strength.

The following are the three methods of testing and
estimating the tenderness in cotton, viscose and the like
fabrics which have cellulose as their chief ingredient:—

(*a*) METHYLENE BLUE TEST:—This is only a quali-
tative test,

(*b*) VISCOSITY OR FLUIDITY MEASUREMENT:—This is
both a qualitative and a quantitative test.

(*c*) COPPER NUMBER DETERMINATION:– This is both a
qualitative and quantitative test.

METHYLENE BLUE ABSORPTION:—Oxy-cellulose has
an enhanced affinity for some basic dyestuffs such as Me-
thylene Blue. The tendered and non-tendered portions
are tinted with an equal strength of the methylene Blue
solution, under similar conditions, and in slightly acidic
bath.

The portion which is chemically attacked absorbs more of Methylene Blue whereas the untendered portion absorbs much less.

MEASUREMENT OF FLUIDITY:—It is a recognised fact that the Fluidity of Cotton Cellulose in Cuprammonium solution can be used as a measure of its degree of degradation, the higher the fluidity the greater the degradation, the lower the fluidity the lesser the degradation.

The relationship between the fluidity and the degradation is not clearly understood but is probably related to the fact that degradation results in smaller cellulose aggregates and these disperse in cuprammonium solution causing a higher fluidity than do large aggregates. The cuprammonium fluidity of Cellulose is particularly useful in the control of the manufacture of all kinds of Cellulose products including Nitro-Cellulose, explosives, cellulose lacquors, and rayons. This determination offers the most generally useful method of detecting loss of strength caused by Chemical attack of cellulose in the bleaching and Dyeing of cotton fabrics. It is the only method at present known which indicates without condition or ambiguity tendering produced in cotton by chemical agency.

The cuprammonium solution* and the Viscometers used can be obtained from the British Cotton Research Association (Shirley Institute) Didsbury–Manchester. The composition of the different Cuprammonium solutions

---

Note.—This can also be locally made but in the preparation of cuprammonium solution great care should be taken that it gives uniform results and is not decomposed during storage.

is found to be near about as follows :

2 litres of the solution contains,

Copper	...	15·00 grms. per litre
Ammonia	...	244 grms. per litre
Nitrous acid	...	31 grms. per litre

The bottles of Cuprammonium are kept in the dark in order to avoid its decomposition in the day light.

A viscometer of the form shown in figure 30 is used both for dissolving the cotton in the Cuprammonium solution and for determining the fluidity of the cotton solution.

The wide body of the instrument has an internal diameter of one cm. and a length of approx. 26 cms whilst the lower capillary D is 2·5 cms long, with the internal diameter of 0·088 cms and external diameter of 0·60 cms. The wide portion is etched with two rings B and C at height of 6·2 and 24·2 cms vertically above the flat end of the lower capillary and the upper end of the instrument is closed with a rubber stopper carrying a second capillary E, the dimensions of which are unimportant. Each Viscometer is provided with a steel cylinder F 2·7 cms long, made from 1/4 of an inch steel rod. The lower half of this cylinder is wedge shaped and notched as shown in the figure and its weight is 5·6 ± 0·2 grms,
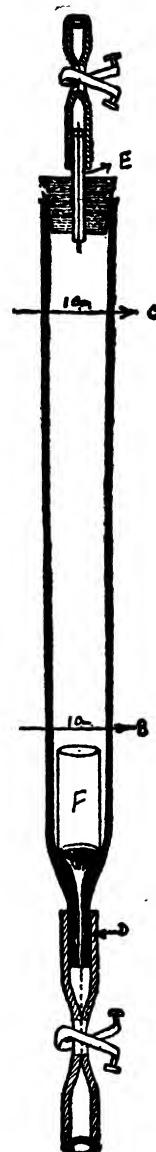

Fig. 30

The measurement is made with a solution contain ing 0·5 grms of dried cotton in 100 cc of solution and for each instrument a record is kept of the weight of material required to yield a solution of this concentration when dissolved in the volume of Cupprammonium necessary to fill the Viscometer.

The fabric under Experiment is very finely cut across the length and breadth by a pair of scissors into very small pieces so as to break warp and weft completely. After the lower capillary is closed with a short length of pressure tubing and clip, the Viscometer with the weight in position is filled, 3/4 full, with cuprammonium sulution, a few drops are run out of the bottom and the pre-determined weight of the cotton added and mixed rapidly with the solvent by means of a thin glass rod. The Viscometer is then completely filled with the cuprammonium, and the stopper inserted so that excess of liquid, displacing all the air, overflows through the top capillary and rubber tube. The latter is closed with the clip, the stopper wired into position and the Viscometer, wrapped with black cloth, is bound to the spokes of the bicycle wheel rotating at four revolutions per minute. The agitation produced in this way by overnight running is sufficient to ensure complete and homogeneous solution of the cotton—a wheel rotating at the rate of four revolution per minute being suitable even for the most viscous solution encountered. About 0·100 grams of the cotton is used for about 20 ccs of Cuprammonium solution in the Viscometer. For different sizes of Viscometers different weights of cotton is used.

In order to measure the flow of the cotton solution the Viscometer is removed from the wheel, the lower

tube and the clip withdrawn and the instrument placed in a thermostat at a temperature of 18-20° centigrade.

After this temperature is acquired the Viscometer is placed in a glass jacket. The shape of the jacket is such that the Viscometer rests on three glass points at the bottom and a sliding fit at the top in the constricted neck. The upper clip is then opened, the stopper removed and the solution allowed to flow freely through the lower capillary. The time in seconds, necessary for the liquid meniscus to fall from upper to the lower ring, is noted.

If F is the fluidity of any true viscous liquid, *d* its density, *t* its time of flow in the standard Viscometer then provided rate of flow is not too rapid.

$dF = C/t$, where C is a constant.

The value of C for different Viscometers has been determined by measuring the time of flow of a glycerine solution of specific gravity $1\cdot1681$ in air at 20°C compared with water, the fluidity of which has been measured by direct comparison with water in an Ostwald Viscometer.

The density of cuprammonium cellulose solution is assumed to be equal to that of cuprammonium itself namely $0\cdot93$ and hence for such solution,

$F = C/ \cdot93\ t$. (from the previous relation)

$= C' / t$, where C′ is another constant and is known as the constant of the instrument.

Thus knowing the constant of the instrument and the time of flow of the cotton solution the Fluidity can be calculated.

When the cotton is highly tendered the solution consequently very fluid and hence rapidly flowing it is

necessary to apply a correction for the Kinetic energy of the liquid. When the flow of the liquid in the Viscometer is rapid its rate is less than corresponds with the actual fluidity of the liquid, the difference being usually ascribed to the fact that energy is consumed not only in overcoming the internal friction but also in imparting the Kinetic energy, associated with the rapid motion of the liquid. To obtain the accurate values this must be allowed for and it is usual to deduct from the value found for the Fluidity a correction which is inversely proportional to the time of flow.........For rapid flow,

$$1/Fd = t/C - K/t$$

where F is the fluidity and K is the constant for the given Viscometer and K/t is the kinetic energy correction. The corresponding equation for the calculation of the fluidity, then becomes,

$$dF = 1/ (t/C - K/t)$$

(C) COPPER NUMBER DETERMINATION

Alkaline solutions containing copper are useful since they are capable of being reduced by degraded cellulose. When tendered cotton is heated with Fehling solution a red precipitate of cuprous oxide is formed. Under similar conditions pure normal cellulose does not produce this precipitate. It is found that cellulose which has been degraded by treatment with oxidising agents is able to reduce an amount of cupric hydroxide approximately proportional to the degree of its degradation. The reducing property of the tendered cotton (oxidised cellulose) is attributed by Wiltz to the action of cellulose-glucose which is formed as a secondary substance on the oxidation of the cellulose.

The behaviour of pure and degraded cellulose towards fehling solution has been closely studied by Schwalbe, and the method* devised by him is described in his book, Die chemische Betriebs-Kontrolle in der Zellstoff-und Papier-Industrie.

*250 cc of distilled water and 2-3 grms of air dry sample of cellulose are placed in a flask of 1500 cc. capacity and heated to boiling with stirring. Through the condenser passes a stirrer. Then a 100 cc of Fehling solution are heated to boiling and added to the cellulose through a dropping funnel, the latter being washed down with 50 cc of boiling water. The contents of flask are then gently boiled for exactly 15 minutes with stirring. 1 grm of purified kieselguhr in 50 cc of water is added and the contents of the flask are then filtered at the pump through double filtered paper in Buchner funnel, the residue being washed with hot water until the filterate is free from copper, as tested by means of a solution of Pot. Ferrocyanide. Subsequently the contents of the Buchner funnel are heated with 6·5 % nitric acid on a water-bath till the precipitate of cuprous oxide is dissolved. The product is then filtered as before, the last traces of copper retained by the cellulose residue being finally removed by washing with a little strong ammonia solution and then hot water. The combined filterate and wash liquors are then evaporated to a small bulk and the copper content determined by electrolysis. The number of grams of copper thus obtained per 100 grms of cellulose is the copper number. The fehling solution is prepared immediately before use by mixing equal volumes of the following stable solutions :

1.   138·6 grms of pure copper Sulphate are dissolved in water, diluted to 2 litres and the solution filtered through linen.

2.   692 grms of pure Rochelle salt and 200 grms of alcohol purified caustic soda are dissolved together in water, the solution being diluted to 2 litres, and filtered through asbestos.

(ROCHELLE SALT=SOD. POT. TARTRATE.)

22

In a recent paper by Eric Hagglund the method of Schalwbe has been modified and the strength of Fehling Solutions No. 1 and 2 changed to different concentrations and the time of heating the cellulose solution reduced to 3-5 mins. It has been claimed that this method* gives a better result and is more handy and simple to be operated in the mill.

---

*The solutions necessary are the following:—

(a) 125 grms of pure copper sulphate dissolved in water and made upto 2 litres.

(b) 400 grms of pure Rochelle salt and 300 grms of caustic soda are dissolved together in water, the solution being diluted to 2 litres.

I grm of the air dry material is boiled with 20 cc of solution (a) and 20cc of soln. (b) for a period of 3-5 minutes (exact period of 3 minutes suggested), after which the material is filtered through a special filter and washed several times with water. The heating of the cellulose material is carried out in a procelain dish. The contents are then drained three or four times with 10 cc of Ferric Sulphate Solution, of a certain strength, and the reduced Ferrous salt is then titrated with N/10 Pot. permanganate solution.

Hey's micro method† for the determination of copper

† In this method the following solutions are necessary :

1. 150 grms of anhydrous Sodium carbonate and 50 grms of sodium bicarbonate dissolved in distilled water to a litre.

2. 100 grms of crystallised Copper Sulphate dissolved in distilled water to one litre.

3. 40 grms of ferric Sulphate and 100 cc. Conc. Sulphuric Acid dissolved in distilled water to a litre.

<div align="center">or</div>

100 grms of Iron alum and 140 cc. conc. Sulphuric acid dissolved in distilled water to a litre.

4. 0·40 N. Potassium permanganate solution.

A deep water bath having a constant level is fitted with a lid of heavy brass of 1/3rd inches thickness. Holes in this lid are bored to suit the thickness of the test tube so that the tubes are a close sliding fit. When they have the liquid in them the tubes will submerge in the bath so that about an inch projects above he lid.

Test tubes 4 x $\frac{3}{4}$ inches each containing ·25 grms of air dry cotton cellulose are put in the holes of the metal lid of the water bath.

To 9·5 cc. of soln. (I) is added ·5cc of soln (2), the mixture is heated quickly to boiling and poured over the weighed cellulose allowing to drain for half an. hour.

The weighted tube is at once immersed in a constant level water bath filled with boiling water to such a height that the other surface of the liquid in the tube is below the liquid of the boiling water and the water bath is covered loosely with the lid. The bath is allowed to boil briskly for three hours. After the boiling is proceeded for ten minutes the Cellulose is stirred with a glass rod to release bubbles of carbon—dioxide which will have

number, much simplified by Vashist and Schofield, still

formed and to distribute the cellulose throughout the solution. This stirring is repeated if necessary. At the end of exactly three hours the tube is removed from the water bath and cooled in water. The cellulose and the precipitated cupric oxide are collected at the pump using fritted Jena glass crucible or a gooch crucible and washed with distilled water three times. The crucible and the adapter are then transformed to a clean filter flask of about 100 cc. capacity. It is often found that traces of Cuprous Oxide are deposited on the sides of the reaction tube, sometimes sufficient being present to form a perceptible mirror. There is also frequently a ring of Cupric oxide formed at the surface in the reaction tube which may conceivably contain some cupric oxide. Hence the details of the procedure, for the determination of the cupric oxide.

1·5 cc. of the solution No. (3) are introduced into the reaction tube which is shaken for a few seconds or till all cupric oxide is dissolved.

Without applying any suction the cellulose on the filter is flooded with the solution and the solution allowed to remain there until the darkening which takes place instantaneously owing to the oxidation of the Cuprous oxide to the cupric state, has passed away. Then the suction is applied and the solution withdrawn to the filter flask, the vacuum is then released and the washing of the reaction tube and the irrigation of the cellulose are repeated using 1 cc. solution No. 3. The reaction tube is washed out into the filter and then the cellulose washed three or four times with 2 cc. lots of cold distilled water, squeezing the cellulose with a glass rod flatened at the end after washing.

The filterate and washings are then treated in the filter flask with ·04 N Pot. permanganate solution using a 5 cc. microburette reading to ·005 cc.

The outside of the jet of the micro-burette is coated right down to the edge of the opening with paraffin wax. In this

gives much more accurate results and is very handy to manipulate.

way the drop as it forms can not run back up the glass, it has a very small neck and breaks off when quite small.

The end point is quite sharp and consists in a change from faint green to colourless owing to the pink of the slight excess of Pot. permanganate neutralising the green of the solution.

A blank determination is made using 2·5 cc of Ferric-sulphate and as much distilled water as was used in the actual test. The blank is usually ·025 cc of N/25 permanganate. The results are generally calculated as percentage of Copper on the dry material.

Calculations :

Ice N/25 Potassium Permanganate
$$= ·00254 \text{ grms of copper.}$$

If (X) cc of N/25 Pot. permanganate are required for the titration then the corresponding amount of copper is
$$= ·00254 \ (X) \text{ grms.}$$

This amount of copper corresponds to ·25 grms of cotton taken for the experiment. Therefore the percentage of cotton on the dry material $= 100/ ·25 \ (·0025 \ X)$

In practice the amount of cotton taken for experiment depends upon the condition of the cotton. If the cotton is not much tendered ·25 grms are used but if it is tendered then less than ·25 are taken for the experiment.

If Y grms of cotton are taken for the determination of the Copper number and if X cc of N/25 Pot. permanganate are required for the titration then the copper number is given by the following formula,
$$(·2500) \ X/Y.$$

The micro-method gives just as good results as the Macro-method only that it is more convenient to manipulate and that very small amount of the material can be used to give just as efficient results.

Testing of Coloured fabrics

At the present time no standard exists for determining the fastness of dyed materials and although an earlier start and more progress has been made on this problem in Germany and America, it is probably true to state that no completely satisfactory fastness tests have yet been formulated. However much knowledge has been gainéd by experiments to indicate that satisfactory tests will be formulated in the near future. ·

(1) FASTNESS TO DOMESTIC WASHING—This test must obviously correspond in severity to the conditions which characterise average domestic washing processes. In general, such washing involves immersion and rubbing in warm water containing soap and a small amount o soda or ammonia. Few people can maintain their hands immersed in water above 50 degrees C. so that this temperature may be taken as the maximum to be used in the test. A few special household soaps contain oxidising agents such as peroxides or Aktivin, but since these should not be used for coloured materials, oxidising agents should not be included in the test. Free caustic soda is also not used' in household washing. It is thus evident that a suitable test will involve immersion and rubbing of coloured material in a solution of sóap and

sodium carbonate say 1/2 per cent., at 50 degrees C. for a specifiied number of times. Further since coloured goods are pressed together in household washing, the test should include the detection of marking off.

The following test is one which is not free from objections, but which is nevertheless a serviceable one :·

Plait a strip of the coloured fabric with a similar strip of white similar fabric, and steep for 15 minutes·in a 1/2 per cent. solution of soap and sodium carbonate at 50 degrees C.; during this period squeeze ten times. Remove the twisted strips from the alkaline soap liquor, and without rinsing, place between two white tiles and press with a heavy weight for 15 minutes; then remove the weight and examine for marking off the dye on the white fabric. Then rinse in cold water and dry. Observe the tint of the white strip and the loss of colour of the coloured material. Repeat this test (excluding the pressing) four more times with drying between each test. The tint of the white fabric and the loss of shade of the meterial being tested will indicate its fastness to household washing.

(2) FASTNESS TO WATER :—This is of importance in fabrics which have to stand exposure to rain. The dyed fabric may be plaited together with a white cloth and boiled in distilled water for 10 to 20 minutes. The bleeding of the clour is noted.

(3) FASTNESS TO BOILING AND ALKALIS :—Boil for 30 minutes in a bath of 5 grm. Marseilles soap, 3 grm. soda ash per litre, cool in bath ·at 40°C. for 30 minutes, squeeze out, rinse, and dry as above. Compare with original,

A German Commission in 1921, fixed, the following standards for tests for fastness of dyes :—

The coloured fabric was braided with equal amount of pure white cotton cloth, and immersed in water.

Test 1. Add 2 grm. of Marseilles soap to a litre of water, and wash at 40°C. for 30 minutes ; take out cotton, squeeze in hand, place again in the bath, repeat ten times, then rinse in cold water and dry.

STANDARD 1. · Dyed cotton slightly faded, white cotton coloured.

STANDARD 2. Dyed cotton fast, white cotton un-affected or very slightly tinted.

The amount of water used is fifty times the volume of the white cotton.

Test 2. Dyed cotton and pure white cotton manipulated as for Test 1.   Add 5 grm. Marseilles soap and 3 grm. carbonate of soda to each litre of the bath, boil for 30 minutes, cool down to 40°C., leave in the warm water another 30 minutes, squeeze ten times as before.

STANDARD 1.   Dyed cotton fades considerably ; white cotton only slightly coloured.

STANDARD 2.   Dyed cotton unchanged, white cotton only slightly coloured.

(4) FASTNESS TO ACIDS :—This test is chiefly applied to weak colours.   The dyed material is immersed for some time in a 5 per cent solution of acetic

acid or a weak solution of hydrochloric or sulphuric acid, (say 1/10th. per cent. Sulphuric or Hydrochloric acid solution). Dyed goods when so treated should show no bleeding.

(5) FASTNESS TO IRONING .AND STEAMING :—Some colours possess the drawback of volatilising from the fabric, in the process of steaming or hot pressing (in finishing and laundry) and their use on fabrics commonly requiring hot press finish should therefore be generally avoided.

In order to ascertain the fastness to ironing and steaming, the pattern may be placed between sheets of filter paper and pressed with a heated flat iron. The bleeding if any should be noted.

Class I—Colour strongly changed and bleeds on to white filter paper.

Class II—Colour slightly changed, no bleeding on to white filter paper.

Class III—Colour not changed, no bleeding on to white filter paper.

(6) FASTNESS TO FRICTION AND RUBBING :—Basic colours are as a rule very bad towards Rubbing and these should be avoided where the fabric has to stand much wear and friction.

The dyed fabric is rubbed on a piece of white calico or on a sheet of a white paper. The bleeding should be noted. Indanthrenes (vat colours) and mineral khaki are the best towards friction and rubbing and so are, to a lesser degree, azoic, naphthols and sulphur colours.

DYE FASTNESS TESTING MACHINE

(FOR TESTING THE FASTNESS OF DYES TO RUBBING)

This machine has been designed to give an accurate and comparable impression showing the fastness to rubbing of various dyes, and can be used on fabrics equally as well as yarns.

The usual method of rubbing by hand is quite unreliable and depends entirely on the unkown pressure exerted and other factors, any one of which may vary owing to the human element.

The illustration (fig. 31) shows the machine with a portion of a hank (2/21s worsted) wrapped on the drum and the rubbing medium or shoe in operation.

In making a comparison of two samples (say yarns) it is essential that if scoured they should have received the same treatment, viz., the same length of time in a liquor of similar constituents, concentration and temperature.

The illustration shows how the rubs or impressions appear, and it will be appreciated that an unskilled person can easily differentiate between the density of any two or more of these.

If still more discrimination is required and a permanent record wanted, they can be obtained by means of a Lovibond Tintometer (British Drug Houses pattern), and the results entered on a Lovibond chart showing the matching standards. If matching blacks, a Cambridge Instrument Opacity Meter may be employed, the figures representing

light reflected from each "rub" as a percentage from that reflected from white fabric, pure black being taken as 0% and pure white as 100%:

CONSTRUCTION AND OPERATION:—The machine is a self-contained unit and can be operated from the ordinary lighting circuit by means of the lamp plug and flex provided. The motor shaft is coupled through a worm reduction gear box with ball, thrust bearings, to the drum which is of aluminium, accurately turned to 36 in. circumference by 4½in. wide. In the periphery of the drum a slot is provided so that the filter cloth base can be tightened by means of a spool, which can be quickly removed when a clean cloth is necessary.

The rubbing shoe is of standardised weight, pivoted in centres, and similarly fitted with two spools so that the rubbing cloth can be wound progressively over the spools, and a large number of rubs made on the same cloth. The complete shoe can be raised up out of the way when threading the yarn on the drum or for fitting a fresh filter cloth; whilst it is automatically put in and out of contact with the yarn or cloth by means of a cam motion. driven from the drum shaft, so that every sample gets exactly the same amount of rubbing.

The "resistance" shown enables the machine to be started slowly to avoid breakage of the yarn. A fine thread screw is fitted to spread the yarn evenly on the drum, and three different spacings are obtainable; whilst provision is made for varying the tension on the yarn for say different counts or when wound from a bobbin or hank.

GOODBRAND & CO LTD
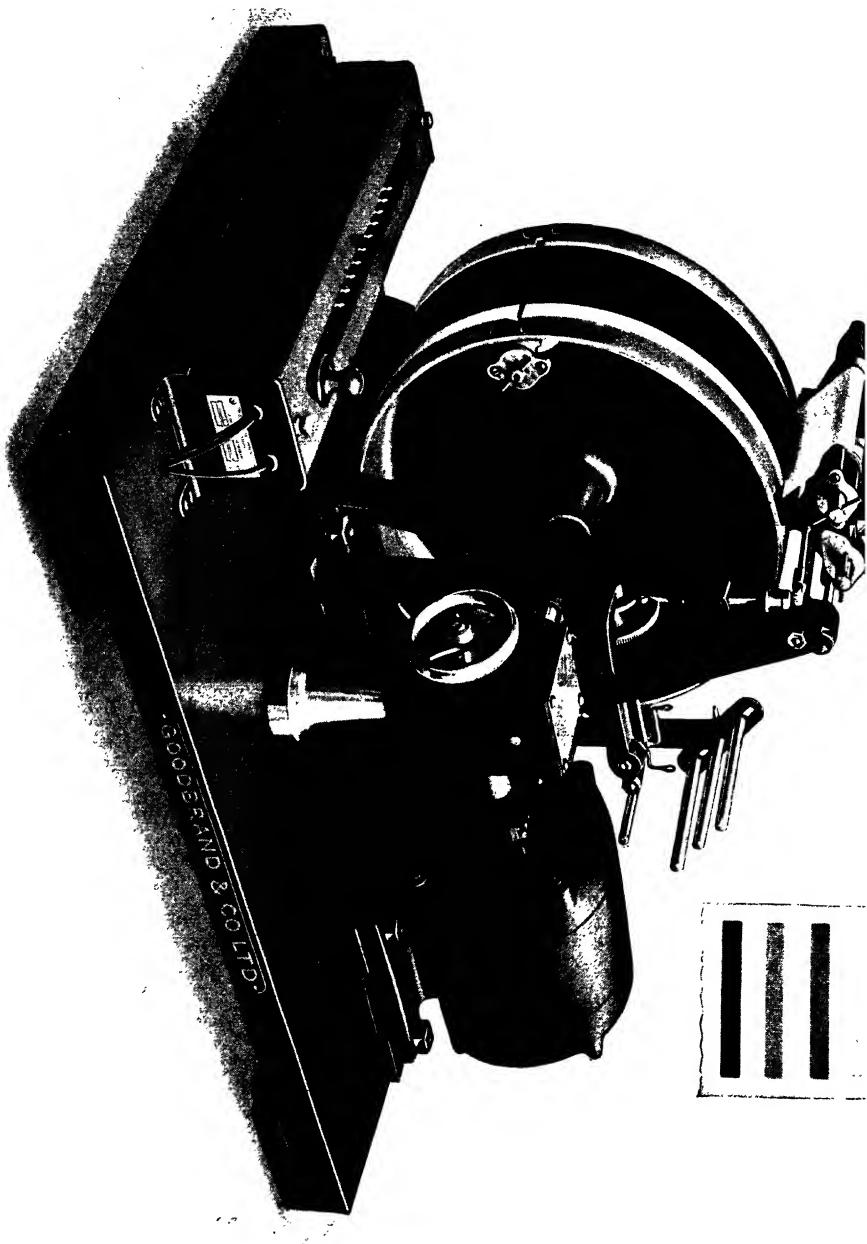
Although it is not absolutely necessary to have a cloth surface on the drum, a lightly stretched good quality filter cloth provides a better base and ensures that little or no lateral movement of the yarn on the drum takes place.

(7) FASTNESS TO STREET DIRT AND MUD:—The street dirt and mud is known to have a destructive action on certain colours especially those used in ladies' dress goods. This destructive action is generally supposed to be due to Limestone or to an alkaline action of the mud caused by the pressure of decomposing nitrogenous matter.

The dyed pattern is either spotted with a 10% solution of sodium carbonate or with quick lime made into a paste in the water, allowed to dry in the air and crusted. The results are noted.

(8) FASTNESS TO PERSPIRATIONS.—A perspiration test is based on the fact that human perspiration is acidic but capable of becoming alkaline through decomposition of its 'nitrogenous constituents,' and that it contains chlorine as chloride. The dyed material is impregnated with a solution containing 1 per cent of Sodium chloride and 0·1 per cent of acetic acid, then allowed to air dry, and the change of colour observed. Afterwards, another sample of the fabric should be impregnated with a similar salt solution containing 0·1 per cent of ammonia instead of acetic acid, dried, and the colour changes observed. It may be desirable to twist the coloured fabric with white fabric in these tests in order to observe the bleeding such as may occur when garments are worn.

(9) FASTNESS TO BLEACHING.—When testing the fastness of a dyestuff to bleaching the fabric must be passed through all the operations through which it would pass in the Bleach croft. Cotton and vegetable fabrics should be boiled, washed, bleached with chemic and soured with acid and if the colour bleeds in any of these operations, it is not fast to Bleaching but if it does not bleed then it is supposed to be fast.

Coloured wool should be bleached with sulphur dioxide and sodium sulphite solution and if it stands the bleaching action the colour is fast.

(10) FASTNESS TO SUNLIGHT:—(ACTION OF LIGHT ON COLOURED FABRICS):—The fading of a coloured fabric in sunlight is dependent on (1) the intensity of the light (2) the wave length of the incident light (3) temperature of the fabric, and (4) the humidity of the surrounding air.

In places where there is sufficient amount of good sun light the method of testing is as below :

The dyed pattern is tightly fixed in a metal frame and partly covered with black paper and exposed under glass to the action of sun light for a number of hours depending upon the class of dyestuffs used. Fading due to the sunrays is then noted. In England and other places where the weather is very much uncertain and sunlight not much available it is not possible to carry out sunlight test for the sake of rapidity and convenience, light fastness is determined by exposing the coloured material to an artificial source of light. The conditions under which the exposure is made must be accurately con-

trolled, particularly in respect of the four factors noted above. The fadeometer is the most satisfactory apparatus for carrying out light-fastness tests. It comprises a special cabon arc, as a source of light having fading power similar to that of sunlight, a means for ensuring that the patterns are maintained at a moderate but constant temperature and a suitable degree of humidity, and vitaglass protecting covers for the patterns such that all the ultra-violet light from the arc is made effective. The fading effect of such a method of exposure compared with sunlight is determined once, so that correct inferences may be drawn from the fading of coloured materials tested by it. Fastness to light is very important, particularly in the dyeing of curtains, etc., which are more or less continually exposed to direct sunlight. Only dyestuffs possessing good fastness to light should be employed ; as a rule the red, yellow, brown, and black dyestuffs surpass the green, blue, and violet dyes. Many of the acid and substantive dyes are moderately fast to light, whereas the basic dyes are, on the whole, fugitive. Indanthrenes dyestuffs (Vat colours) manufactured by I. G. Farbenindustric Aktiengesellschaft, Frankfurt, Germany are supposed to be the fastest colours to light and fabrics which have to stand long exposure to light are usually dyed with these dyestuffs. Schofield and Vashist have shown that the so called fadeless Vat dyed cotton fabrics, when exposed to sunlight for a long period, not only fade but also act as catalysts in tendering the cellulose of the cotton fibre. The fading of some of these dyestuffs in relation to the tendering produced on the fibre is shown in the table below :—

Two months exposure in Manchester sun
(July and August)

Sateen dyed with	Tendering of the Fibre.	Fading of the Dyestuff.
Undyed, bleached Sateen ··· ···	x	...
Cibanone Yellow R. ··· ···	xxxx	xxxx
Cibanone Yellow 2G ··· ···	xxxx	xxxx
Cibanone Yellow 3G, ··· ···	xxxx	xxxx
Hydron Yellow GG. ··· ···	xxxx	xx
Anthra Yellow GC ··· ···	xxxx	xxx
Hydron Yellow NF. ··· ···	xxxx	xx
Ciba Yellow G. ··· ···	xxxx	xxxx
Cibanone Gold Orange 2G. ···	xxx	xx
Duranthrene Yellow YP. ··· ···	xxx	xxx
Indanthrene Yellow GF. ··· ···	xxx	xx
Helindone Orange GRN. ··· ···	xxx	xxx
Duranthrene Gold Orange Y. ···	xxx	xx
Ciba Orange G. ··· ···	xxx	xxx
Algol Yellow R. ··· ···	xx	xxxx
Indanthrene Yellow FFRK, ···	xx	xx
Duranthrene Yellow R. ··· ···	xx	x
Indanthrene Yellow GK. ··· ···	xx	xx
Indanthrene Yellow RK. ··· ···	xx	xx
Indanthrene Orange 4R. ··· ···	x	x
Indanthrene Yellow G. ··· ···	x	x
Duranthrene Gold Orange 2RT ···	x	x
Alizanthrene Yellow 6R. ··· ···	x	x
Cibanone Orange 6R. ··· ···	x	x
Indanthrene Yellow GGK. ···	x	xxxx
Indanthrene Orange 3R. ··· ···	x	xx
Caledon Jade Green ··· ···	x	x
Indanthrene Yellow 3RT. ···	x	x
Indanthrene Yellow 3GF.··· ···	x	x
Duranthrene Blue GC. ··· ···	x	x

Note.—xxxx Very Much.
    xxx Much.
    xx Appreciable.
    x Very Little

From the above it can readily be seen that some Vat colours fade more than others ; also some tender the cotton more and some less. How and why this happens, is not the intention of the author to discuss here in these pages.

11. FASTNESS OF MINERAL KHAQI COLOURS :—

(a) Boil the khaqi dyed material with a weak solution of soda carbonate for about 30 minutes. If the colour stands this treatment it is fast to washing.

(b) Soak for 30 minutes in a cold solution of Hydrogen Peroxide. If the colour stands this test it is fast to air and light.

(c) Steep the sample in Lactic acid solution for 24 hours (acid Sp. gravity 121 U. S. P.) or in a solution of citric acid (3 dr. acid to 2 fluid oz. cold water) and if the colour stands these test, it is good enough for any practical purposes and also fast to laundering and perspiration etc.

IDENTIFICATION OF DYESTUFFS USED FOR DYEING TEXTILE MATERIALS :—

The following class of Dyestuffs are commonly used in Dyeing both vegetable and animal fibres and before these can be successfully detected a sound technical knowledge and experience of the various methods of application of these on the various Textile fibres, is essential and necessary to possess :—

DYESTUFFS USED :—

(1) Direct dyes.

(2) Basic dyes.

(3) Sulphur colours.

(4) Acid dyes.

(5) Azo dyes and Naphthol A. S. colours.

(6) Turkey red and Alizarine red, chocolate and purple.

(7) Aniline, Black.

(8) Mineral Khaki colours.

(9) Vat (Indanthrenes) colours.

DETECTION OF DYESTUFFS

Experiments	Observations	Inference.
(1) Boil a small piece of the dyed fabric with water and a little soap.	(a) Colour bleeds profusely.	Direct colur.
	(b) If cotton fabric, the colour bleeds profusely, without the addition of soap.	Acid colour.
(2) (a) Boil a small piece of the dyed fabric with 2 p. c. Hydro-chloric Acid.	(a) Colour destroyed; yellow solution goes violet with alkali.	Turkey Red and alizarine reds, chocolates, and purples.
	(b) Wine red solution.	Logwood Black.
	(c) Goes instantly black, restored with ammonia.	Benzopurpurine and Congo reds
	(d) Little altered.	Direct colours, Vat colours, Sulphur, azoics & naphthols.
(b) If Logwood Black, boil with sulphuric acid.	Sample decolourises and the solution turns reddish.	Logwood Black, Confirmed.

DETECTION OF DYE-STUFFS

Experiments	Observations	Inference
(3) Boil with 2 p.c. Hydrochloric acid and a small piece of zinc. or Boil the sample with Titanous chloride	(a) Colour discharged to white or yellow.	Direct colour.
	(b) Colour completely discharged. Fibre remains a dull yellow or brown colour.	Basic colour.
	(c) H_2S (Hydrogen sulphide gas) given off. Turns Lead Acetate paper Black.	Sulphur colour or Hydron colour.
(4) Boil the sample with 5 p. c. Caustic soda sulution.	(a) Colour destroyed.	Basic, chrome, yellow—Prussian Blue.
	(b) Violet solution (yellow with acid).	Turkey red, alizarine red, chocolate or purple.
	(c) No effect.	Sulphur, Vat, (Indanthrene) aniline or Black.
(5) Boil the sample with weak ammonia and add a piece of white cotton.	(a) Considerable bleeding.	Acid colour.
	(b) Considerable bleeding, white becomes stained.	Direct colour.

Test	Observation	Dyes
(6) Treat the sample with warm bleaching powder solution (Slightly acidic with acetic acid.)	(c) Little or no bleeding, white cotton unstained.	Sulphur, Vat (Indanthrene) Basic mordant, naphthols and azoics.
	(a) Colour destroyed.	Direct colours, Sulphur colours, Basic colours. Turkey red and Para red and Alizarine Red.
	(b) Colour goes brown.	Aniline Black or Diphenyl Black.
	(e) Colour slowly destroyed.	Hydron colours.
	(d) Little or no effect.	Indanthrenes (Vat colours) mineral khaqi colour; naphthol red.
(7) Take the sample and char it with concentrated sulphuric acid and add to a large quantity of water.	(a) A green colouration (presence of chromium).	Aniline Black.
	(b) A brownish colouration.	Diphenyl Black.
	(c) Yellow colouration, white changes to violet on addition of excess of caustic soda.	Alizarine Turkey Red.
	(d) Pink colour.	Naphthol Red.
(8) Treat the sample with hot chloroform.	(a) Coloured solution.	Indigo Vat, para red, azoics, naphthols.
	(b) No coloured solution.	Hydron colour, Direct, sulphur colour if properly fixed on the fibre; Alizarines, mineral colours.

DETECTION OF DYESTUFFS

Experiments	Observations	Inference
(9) Boil the sample with Hydro-sulphite and caustic soda.	(a) Colour destroyed.	Direct colour—Para Red—naphthol Red.
	(b) Colour destroyed but comes back on washing or airing.	Sulphur colours, Indigo or Vat dyes (Indanthrenes), Hydron Blue.
	(c) Colour changed but restored in air.	Anthraquinone Vat colour.
	(d) Not destroyed.	Aniline Black and Logwood Black.
(10) Place a few drops of concentrated Hydrochloric acid on the sample and note the colour of the patch.	Green or Greenish patch.	Chrome (mineral) khaqi.
(11) Burn a piece of the sample and note the colour of the ash.	Brown or dark brown.	Chrome or mineral khaqi

Chapter VII

DEFECTS IN TEXTILE GOODS—THEIR CAUSES, PREVENTION AND REMOVAL

CHAPTER VII

Defects in Textile goods—their causes, Prevention and removal.

It is essential that those engaged in the Textile Industry should know the cause and origin of certain defects that are common to Textile fabrics, and also the method of their removal and prevention. With this aim in view this chapter has been written and it is hoped that it will prove useful to those who are interested in this particular aspect of Textile testing. This branch of Technique may be divided into three headings:—

(1) Defects in yarn.

(2) Defects in woven cloth.

(3) Defects in knitted fabrics.

(4) Defects in Rayon materials.

(1) *Defects in Yarn*:—

Yarn, as a material, is required for a large variety of cloths, and consequently the features required in some yarns may be a disadvantage in others. It is essential that every yarn should be judged according to the particular type of fabric for which it is intended. The defects common to all yarns may be divided into three

25

groups which individually and collectively are responsible for the majority of yarn faults:—

(1) Defects due to the raw material.

(2) Defects due to inefficient manipulation and settings of the spinning machinery.

(3) Defects due to subsequent operations.

The quality of the raw material will determine to a great extent those variations in physical features which yarn usually suffers from, although efficient spinning may tend to counteract their magnitude. Irregularity in appearance, then, is a comparative defect in yarns.

Regularity in yarns demands regularity in the supply of the material at each of the spinning operations. Absence of one or more slivers or rovings during any of the spinning processes will produce a thin place, while bad piecings may cause thick and thin places to be formed.

The setting and the conditions of the rollars in the various spinning machines require considerable attention, so that the material is efficiently drawn to maintain regularity.

In the actual spinning operation the tension in the spindle bands should remain as constant as possible if regularity is to result.

Though every effort be made on the part of the spinner to produce correct counts, uniformity of this factor is almost impossible.

A serious defect in yarns for certain classes of work is the variation in the number of turns per inch. Although the correct number of turns may be inserted by

the spindle, they may not be equally distributed over the length of yarn. The twist will be more numerous in the thin places, and the other portions of the yarn will have less turns than was intended.

The strength of a yarn depends upon the correct manipulation of the material at every point of its manufacture, so that the irregularities mentioned above have their effect upon the strength. Variation in strength causes more trouble in all subsequent operations than any other defect.

Tender yarn may be caused by injury to the fibre during the initial spinning operations; to excessive draft and pressure in the drawing and flyer frame processes; by loose hands, worn parts, improper timing, and too much strain placed on the yarn in mule spinning, while imperfect travellers and bad adjustment of ring spindles and thread guides will lead to the production of tender yarn on the ring spinning machine.

If, during the final spinning process the tension is removed, or the thread is allowed to go slack, there is a tendency for the material to form into a small loop or snarl. This is more prevalent when material of a lower grade is being spun, and to get the required strength, a slightly higher twist constant is used.

Dirty yarn may be caused by insufficient cleaning of the cotton; the use of too much oil, and neglect to clean the machinery properly.

The operations which follow the spinning process will depend upon the type of yarn dealt with, and the particular type of cloth to be produced. The weft yarn

for the grey trade is generally in a suitable form, and is ready for the loom as it leaves the final spinning machine. Warp yarn for the ordinary class of grey trade is supplied to the manufacturer in the form produced on the spinning machine, and then passes through the operations of winding, warping, sizing, and drawing-in, to be ready for the loom.

The winding operation is the last process where the material is treated in the individual thread form, and it is in this process that weak places, slubs, and snarls should be removed. Efficient clearer and tension devices are essential for this purpose. The thread on the bobbin should be continuous from one end to the other, and in as perfect a condition as possible.

In warping, every thread should be wound on to the beam with uniform tension and a level beam produced. Any thread breakage should be repaired with as small a knot as possible.

Coloured yarn for the grey trade and yarn for the coloured trade may pass through a series of operations, such as :—gassing, mercerising, dyeing, sizing, etc.

Gassing or singeing may weaken the yarn, if the yarn is in contact with the flame or hot plate too long, while tender yarn may be caused in bleaching by the use of too strong a "chemic" solution, by the "bowking" solution being too hot, or, by insufficient washing of the yarn after bleaching.

The chief defect associated with the dyeing process is the lack of uniformity in depth of colour throughout a batch of material,

The process of sizing, which may be carried out before or after the yarn arrives at the mill, may introduce defects into the yarn if it is not carried out efficiently. The defect known as "brittle" yarn may be caused at this process in different ways ; the use of an unsuitable sizemixing-too much adhesive matter for the type of goods—or an insufficient quantity of softner will tend to produce this defect in the yarn. The same defect may be caused by over-drying the yarn as it passses round the cylinders; while too much tension placed on the yarn during its passage through the machine will impair its elasticity.

Where the heating of the size is done by live steam, there is a tendency to dilute the size by the condensation of the steam, and so reduce the viscosity of the solution and produce undersized warps, while, if the heating arrangement is not distributed uniformly the size near the ends of the box does not maintain the same concentration as the size in the middle of the box, and, consequently warps with "soft" may be produced.

If the yarn is passed on to the eawvers' beam in too damp a condition there is a greater tendency for mildew to develop.

Whatever process of preparing the weavers' beam is used, it has as its object the placing on a beam in sheet form the required number of threads for the cloth to be produced, such that, every thread occupies its own relative position throughout, and that each thread is continuous of the same length from end of the beam to the other end,

(2) DEFECTS IN CLOTH:–Many of the defects associated with cloth are attributable to defects in the material, and faulty preparation, while bad manipulation and sett ings during the actual weaving operation may produce various faults in the woven fabric.

Probably the commonest fault of all is the missing of warp threads either individually or collectively at different places in the cloth. This may be due to a weak place in the yarn caused by the quality of the raw material or by inefficient spinning, a fault which should have been removed in the preparatory operations; by overstraining the yarn during its preparation so that it is not able to withstand the strain of the actual weaving process; by insufficient or unsuitable type of size mixing by excessive tension on the warp yarn in the loom; and by making large sheds. Where a thread is missing a thin place appears in the cloth down the piece. If the thread is not repaired or straightened out immediately, the broken end tends to get entangled with other threads and stop them from interweaving according to plan, producing what is known as a " float. " In high-grade cloths this defect can only be remedied effectually by unweaving the piece, while in low qualities the operative tries to repair this defect by " spireing " and scratching up with a comb.

The even distribution of the warp threads over the whole width of the cloth produces a well-covered cloth, but as the threads are generally drawn through the reed in groups of two, three or four, there is a tendency for them to appear in the cloth in a similar grouping. This results in what is termed "bare" or "ready" cloth. The

amount of cover is determined by the strain that is placed upon the warp threads, the position of the two lines of warp at the beat up and the rolling action of the weft.

Although the selvedge may not be very important during the ultimate use of the fabric, it is essential to provide suitable selvedges for the manufacturing and-finishing processes. The defects may be in appearance only, or may cause serious trouble in the finishing due to faulty construction. The primary object of the selvedge is to assist in the weaving operation by adding to that portion of the warp subjected to the greatest strain. Excessive or irregular tension on the weft, will tend to produce a sevrated edge, while insufficient tension in the wefts or shuttle rebounding in the box will tend to produce loops in the selvedge. Badly wound beams or loose flanges will cause irregularity in appearence of the selvedge, as well as making the weaving process more difficult. Faulty construction of the selvedge, either as regards the number of threads per dent or the counts of the material, will cause damage to occur to cloth during the finishing operations due to the difference in strength and stretch between the body cloth and the selvedge.

The defects known as " cracks ", "thick and thin" places, may be caused by carelessness on the part of the operative or by the failure to act, and, or the faulty setting of the loom parts. These defects most commonly occur when the loom is re-started after changing the shuttle to replenish the weft. If the finger is held back too long a thick place will be formed, and if the finger is not held long enough a thin place will result, while it is

very common to see a thin place followed by a thick place due to imperfect readjustment of the loom's take-up motion after the loom has stopped. The defects may be caused while the loom is running by faulty setting of the take-up motion ; weft-form motion not stopping the loom when the weft breaks, and the weft catching on again ; the sand or emery roller not gripping the cloth sufficiently ; irregular let-off of the yarn from the loom beam ; uneven shedding ; reed not firmly fixed in the reed case, etc.

In cloths using coloured weft that has been dyed in cop form a very common defect is the variation in shade of cloth. This is due to the fact that it is very difficult to dye a batch of cops uniform as to shade by this process, and consequently the shade of the cloth at any place depends on the particular shade of the weft cop being inserted. To get more uniformity in shade of cloth a weft mixing loom is employed. This loom is a two-shuttle multiple box loom, and will insert two picks alternately from each shuttle.

The insertion of a cop of weft of either a different count or a different direction of " twist " causes a change in appearance in the cloth and shows as a distinct fault after finishing.

In stripe and fancy cloth ends out of position or ends drawn through the wrong healds, cause faulty patterns in the warp.

With dobby cloths, wrong lifts may be produced owing to pegs being broken or to pegs coming out of the lags.

Mis-lifts may be produced in Jacquard cloths due to the harness sticking, and by faulty setting of the cylinder and needle board.

In many cloths it is essential that the pattern shall be unbroken from the beginning to the end of the piece. This is the case with twills, satins, checks, etc., and fancy woven cloths using Dobby or Jacquard shedding motions. When the loom stops on account of a weft breakage or the weft supply running out, it is necessary to find the correct lift at which the weft supply exhausted. This is known as " pick and pattern finding," and the operative is expected to be able to restart the loom so that the pattern shows no break.

With fancy check cloths it is necessary that the shedding and the box motions shall work harmoniously together, and this is best attained by working them both from the same source, i.e., the dobby.

Oil stains are produced in cloth by the application of too much oil to the spindle in the shuttle box ; by using newly-oiled pickers with the free oil not removed; by oil from picking bands ; by the weft-form lever tappet extending too far backwards and coming into contact with the yarn on the full weavers' beam. In many cases the operative attempts to wash out the oil stain while the cloth is being woven. If the cloth in its damp state is left in contact with the breast beam after the mill has stopped for the week-end or for a longer period, there is a great tendency for " rust " stains to be produced. This defect may also be caused where artificial humidifying apparatus is used in the weaving shed, causing rust stains to be produced on the warp yarn in contact with the back rest and on the cloth in contact with the breast beam when the mill is not working.

Another stain met with in cloth is produced by mildew. There are substances used in the size mixing which will form a suitable medium for the growth of mildew, but antiseptics may be added to the size mixing to prevent this fungoid growth.

(3)   Defects in Knitted Fabrics :—

Defects in knitted fabrics can be classified as follows :—

A.   Those due to faults in yarns.

B.   Those due to faults in machine setting.

C.   Those due to careless handling of materials.

D.   Those introduced in the finishing processes.

It is not always possible to attribute a defect to any one particular cause to the exclusion of all others. For instance, faults may be assigned to the yarn when they might have been overcome, to some extent at least, by more careful setting of the machine, or an operator may sometimes be blamed for a defect which, through a combination of circumstances, he may not have had the power to rectify.

A.—Defects due to Faults in Yarns :—

(1)   CLOUDINESS :—Thick and thin places, caused by lack of uniformity in yarn diameter.

(2)   COCKLING :—Distortion resulting from the use of harsh and wiry yarns. This defect may be eradicated in some instances by lubricating the yarns, but great care must be taken to see that a suitable lubricant is used and that even penetration is obtained.

B.—Defects due to faults in machine setting.

1. Tuck Stitches : Possible causes are :—

   (*a*) Too little drawing-off power applied to fabric.

   (*b*) Insufficient pressing on bearded needle machines.

   (*c*) Too short a stitch.

   (*d*) Imperfect needles—bent or rough latches, partly broken butts, damaged beards.

   (*e*) Incorrect. timing of pressing and landing movements on bearded needle machines.

2. Dropped Stitches : Possible causes are :

   (*a*) Yarn too lively. Remedy : apply tension and or, lubricate.

   (*b*) Incorrect setting of yarn guides.

   (*c*) Imperfect needles—insufficient clearance between beard and stem (bearded needles), closed hooks (latch needles).

   (*d*) Wrongly adjusted latch guards or brushes on latch needle machines.

3. Cut or partially cut work. Possible causes are :—

   (*a*) Excessive tension on yarn or fabric.

   (*b*) Rough needles or sinkers.

   (*c*) Stitch length too long or too short.

4. " Shirgalling " or Uneven Loops in a Single Course : Possible causes are :—

   (*a*) Wrong angle of stitch cam. Remedy is to file cam to shape so that each loop is drawn to its fullest extent before the next is started.

(*b*) Imperfect alignment of needles.

(*c*) Variation in tension on yarn.

(*d*) Too great a lead of yarn guide over sinkers on straight bar bearded needle machines.

5. Irregular loop length in different courses :—

A defect most common in fabrics knitted on multi-feeder machines and caused either by having more tension on some yarns than on others, or by incorrect relative adjustment of stitch cams. An even stitch length can be obtained by measuring-off an equal length of yarn at each feeder and adjusting tension devices and or stitch cams until the same number of stitches is formed from each equal length.

Where alternate courses have loops of different length in the heels and toes of seamless hose, the probable cause is that the sinker timing is too late or too early in the reverse direction of knitting.

C.—Defects due to operative's careless handing of materials.

1. HOLES IN FABRIC.—The most frequent cause of this is the tying of unwieldy knots. Weaver's knots only should be tied and the ends neatly trimmed.

2. VARIATION IN LOOP LENGTH.—The formation of stitches shorter than normal may result from the mis-handling of wound packages, which cause strands of yarn to become tangled and drag, in off-winding.

3. STAINS AND FUZZINESS.—Rayon yarns must be manipulated at all stages with special care and operatives' hands should be kept spotlessly clean and free from oil to avoid staining the material. Rough hands are likely to cause fuzziness through breaking individual filaments.

D.—Finishing Faults.

1. PATCHINESS.—This is caused by uneven penetration of dyestuffs, but whether the fault is entirely with the dyer depends upon circumstances and is often a debatable point.

2. FABRIC DISTORTION.—The calendering operation performed on fabric in the roll often has the effect of bowing the courses in spite of the use of special tentioning devices designed expressly for the purpose of overcoming this tendency. In the finishing of high-class fabrics it is advisable to obviate the possibility of this trouble occurring by flat pressing instead of calendering.

3. TENDERING OF FABRIC.—Caused by having scouring lye too strong or too hot, or by the use of unsuitable chemical agents in other wet operations. Woollen fabrics are sometimes weakened and their wearing properties seriously diminished by chlorination in the process of rendering them unshrinkable.

(4) Defects in rayon materials

REGENERATED RAYONS.—The regenerated rayons are liable to the usual causes of tendering associated with the bleaching of cotton, but are much more susceptible than cotton. Degradation of viscose and cuprammonium rayons is rapidly brought about by the use of too strong bleaching baths, particularly when used at the neutral point pH 7. Cases have occurred when, in a mixed cotton and viscose fabric, the viscose has been so badly degraded as to have no strength, whereas the cotton has been only slightly affected. Cellulose acetate rayon, being

a compound of cellulose, is even less affected than cotton, particularly if the bleach liquor is on the acid side of neutrality, whereby any danger of saponification is avoided.

Regenerated rayons are also rapidly tendered by strongly acid liquors. If acid is incompletely removed after souring and is subsequently dried into the cloth, degradation quickly results owing to the formation of oxycellulose, as in the case of cotton.

The greater susceptibility of the regenerated rayons as compared with cotton, to acid attack, is made use of in the quantitative analysis of cotton and regenerated rayon mixtures.

Acetate rayon withstands the action of acid even at strengths which will tender cotton. In this connection an interesting case of acid tendering arose within the author's experience, of a fabric containing cotton, viscose, and cellulose acetate. The viscose threads were quite devoid of strength, and easily rubbed out of the fabric, the cotton was much weaker than normal and contained oxycellulose, whilst the cellulose acetate was unaffected.

DETECTION OF TENDERING :—The most usual way of detecting chemical damage is by testing the strength of the suspected material and comparing it with the strength of the same fabric, but in an undamaged condition.

In the case of regenerated rayon it is most important to test the strength in both wet and dry states, for the wet strength shows a greater percentage decrease than the dry strength as a result of degradation.

Tendering may also be detected by making an estimation of the copper number provided that the copper number of the original material is known.

In cases of local damage recourse must be made to a "pictorial method" of detecting the degraded parts, for the copper number is of little or no value in determining the distribution of damage over small areas. The alkaline silver-thiosulphate solution used for the detection of oxycellulose on cotton produces a brown colouration on normal viscose rayon, and the reduction of the silver solution by oxycellulose is therefore difficult to detect.

A Nessler solution of reduced caustic soda content is employed. This solution produces a very light grey colouration on viscose rayons and leaves cuprammonium unstained. Material containing oxycellulose gives a dark grey to black deposit. The fabric to, be tested and a piece of untendered material are boiled in this solution for one minute and rinsed in dilute potassium iodide solution. If the sample under examination becomes more deeply coloured than untendered fabric, oxycellulose is indicated.

CELLULOSE ACETATE :—When cellulose acetate rayon is heated it first becomes plastic and then melts, plasticity becoming noticeable at 180°C. On resolidification after cooling the individual filaments are found to be melted or plasticised together. The threads are very brittle, much less absorbent to water and all dye-stuffs, but are still soluble in acetone, showing that only a physical change has taken place.

Damage to fabrics or garments composed wholly or partially of cellulose acetate, by hot ironing or other dry

heat treatment, is sometimes met with. The tendering is detected by the fact that the affected material is usually quite stiff and sometimes glazed, and the individual filaments are plasticised together.

In the case of fabrics composed of a cotton warp and a cellulose acetate weft, the rayon is often melted round the cotton and firmly adheres to it. The untendered rayon dyes normally, but the tendered rayon is scarcely dyed at all and consequently remains almost the original shade.

Thus if the original shade was blue, overdyeing with a yellow will produce a green on the untendered material, but the damaged portion remains blue.

LOSS OF LUSTRE AND SAPONIFICATION :—When cellulose is boiled for sometime in water it partially or entirely loses its lustre. In alkaline solutions, in addition to loss of lustre, splitting off of some of the acetyl groups takes place, the strength is much reduced and the rayon will now dye with direct colours. If the alkaline treatment is prolonged complete saponification takes place and cellulose is regenerated.

If dulling of the lustre has been produced by boiling in water alone, it can be restored by treatment with acetic acid, phenol, and solutions of ammonium sulphocyanide.

It is possible however to boil cellulose acetate rayons in solutions of various salts, such as sodium chloride, ,sodium sulphate, and ammonium sulphate, without loss of lustre and saponification.

Strong alkali of mercerising strength has practically no action on cellulose acetate at ordinary temperatures for short periods, so that fabrics composed of cotton and cellulose acetate may be mercerised without damage to the rayon.

If tenderness of acetate rayon fabrics is due to saponification it may be detected by dyeing with direct colours which do not normally dye this type of rayon. Any saponified parts will dye in the same way as the regenerated rayons.

DYEING FAULTS:—Unevenness in dyed rayon may give rise to various faults, such as light and dark hanks, "stripey" warps and weft bars, and is due to various causes. Some of these defects are due to faults arising during winding or weaving. If a weft cop of different denier to the usual product is woven into a cloth, a weft bar is produced on dyeing. The dyeing is perfectly even, but owing to difference in thickness and number of filaments there is an apparent difference to the eye. A denier and filament test of the rayon from both light and dark places will show the cause of this type of barring fault.

Uneven dyeing in the piece is also caused by using indiscriminately rayon from various manufacturers. The dyeing affinity of any rayon is likely to vary according to its source.

The faults so far considered are due to faulty cloth manufacture and apply to all types of rayon. Variability in dyeing affinity of the rayon as delivered by the maker of the rayon is the cause of the most usually occurring uneven dyeing defects.

27

In the case of cellulose acetate the affinity for dyes-tuffs is mainly determined by the chemical composition and since this is apparently kept very constant, dyeing faults are much less frequent than in the case of viscose.

The variable dyeing affinity of viscose rayon has been the subject of considerable investigation and it has been found that an increase in tension during spinning gives a product which dyes deeper with direct and vat colours, and lighter with basic colours. It has. also been found that the presence of oxycellulose or similar products plays a very important part in determining the affinity for dyestuffs. Hanks of high oxycellulose content will dye less deeply wlth direct and vat colours and more deeply with basic colours than normal hanks. .

Since viscose rayon is liable to variation in dyeing affinity it is desirable that suitable tests shall be available to determine which dyestuffs will tend to dye evenly on viscose rayon showing the fault.

HALL'S TEST :—A. J. Hall observed that viscose yarns after treatment with caustic soda of three to six per cent concentration, washed first in acid and then with water, showed an increase of affiinity for some dye-stuffs but not for others. The colours which dye un-evenly have an increased affinity for the alkali treated rayon, and those which dye evenly have the same or only slightly increased affinity.

On this observation is based a test to determine whether a particular dyestuff is of even or uneven dyeing. Skeins of yarn forming half of a particular batch of the same dyeing affinity are completely immersed for four hours in a five per cent. solution of caustic soda

at room temperature. The yarn is then washed with water, then soured with hydrochloric acid or acetic acid, finally rinsed well thoroughly free from acid, and subsequently dried.

In order to test the even or uneven dyeing properties of a particular dyestuff, a hank of untreated and a hank of treated rayon are dyed together in the same bath. Colours which show the least difference in depth and shade between the two are those which tend to obscure barring faults.

CAPILARITY TESTS :—If threads of viscose having the same dyeing affinity are suspended so that the lower ends dip into solutions of various dyestuffs, some threads will be coloured to a greater height than others. The dyestuffs which rise highest up the threads will dye unevenly, and those which rise least will dye evenly.

TEMPERATURE RANGE TEST :—(C. M. Whittaker & Courtaulds, Ltd.),

In this test, which is to ascertain whether a dyestuff will dye evenly and tend to cover up or obscure barring faults, eight skeins of viscose of the same dyeing affinity, are dyed in eight dyebaths, one skein in each. The dyebaths are the same in every way except the temperature which varies as follows :—20 degrees centigrade, 30 degrees centigrade, 40 degrees centigrade, 50 degrees centigrade, 60 degrees centigrade, 70 degrees centigrade, 80 degrees centigrade and 90 degrees centigrade. After dyeing the skeins are dried and compared with each other for depth of shade. The most even dyeing colours are those which give the heaviest dyeing at 40 degrees centigrade, whilst colours most liable to reveal variations

of dyeing affinity are those which give the heaviest dyeing at 90 degrees centigrade.

CORRECTION OF UNEVENLY DYED VISCOSE :—(C. M. Whittaker & Courtaulds, Ltd.)

When viscose rayon dyed with direct colours shows unevenness it may be improved by an after-treating process discovered by Messrs. Courtaulds.

The method advocated, is as follows :—

The uneven material is treated for thirty minutes in a bath containing 1 lb. B-naphthol, 1 lb. sodium chloride per 10 gallons of water. The B-naphthol only partially dissolves and fine crystals float on the liquor. After treatment the B-naphthol should be thoroughly washed out of the material in hot water on a soap bath, since any B-naphthol left in the goods is liable to turn brown on exposure to the atmosphere.

Chapter VIII
Inspection of Textile materials
Section I—The Preparation of a Specification

Section II—Outlines of some Specifications

SECTION I

The Preparation of a Specification

To enable inspection to be carried out in a thoroughly efficient manner, the first essential thing is a well prepared specification, to which the various materials should be purchased. In fact, it is well nigh impossible to carry out inspections unless the material has been purchased to a well defined specification. The people entrusted with the task of preparing the specification should consist of spinners, manufacturers, and finishers, the actual users, together with other technical representatives responsible for the purchase or inspection of Textile fabrics. Such a combination of interests is necessary for the preparation of the best specifications, and if it is found to be impossible to have all the specifications prepared in this way, they should certainly be submitted to all these various authorities before final issue. If this is not done, there is always the possibility that they may be vague and misleadng or contain so much detail that the manufacturer will not care to supply material against them.

THE REQUIREMENTS OF A SPECIFICATION:—The specification should in the first place give the quality of the fibre to be used. It will often be found that unnecessarily good qualities of fibre are called for. For example, it app-

ears to be the general rule to specify all long flax for all canvas. Now where the material is to be oil-dressed or proofed, as for tarpaulin sheets, this is necessary since no other fibre will hold the dressing so well, but where the material is to be used in the loom state and strength, closeness of texture, and weight are the only requirements; a good quality hemp would be much cheaper and probably more serviceable. The same remarks apply to many woollen and cotton specifications, in many of which unnecessarily good quality of fibre is called for.

COUNTS:—In yarn contracts the counts of the yarns should be specified, together with the tolerance in counts which will be permitted. In this connection it is necessary to state how the tests shall be made, and also the quantity of material which shall be used in testing. In certain tests which were made recently by the author to ascertain the variation in counts of a 60's silk yarn, quite different results were obtained on making tests on different lengths of yarn. When tested on 1/8 leas the counts varied from 52·1's to 75·3's, when tested on 1/4 leas from 54·1's to 69·7's, 1/2 leas from 55·3's to 67·7's, and on full leas from 58's to 65·9s. From consideration of these results, it will be realised that the variation in a yarn count depends to a considerable extent on the length of yarn tested. As a general rule, 10 leas should be taken from each of the selected bundles of yarn, and each of the leas be weighed, the count calculated from their total weight, and the variation given as from lea to lea.

Where a compound yarn is required the specification should give the yarn structure, and if the yarn is to

be treated in any way it should specify the treatment. Thus, for instance, linen yarns are often supplied once or twice boiled, quarter, half, or fully bleached. Single thread strength tests are much more satisfactory than lea strengths, although spinners generally prefer to sell to the latter. It will sometimes be found necessary to specify elongation of the yarn under certain loads and at breaking point, and in such cases it will be necessary to specify that a given weight be hung on the yarn before clamping it in the jaws of the testing machine.

All yarns should be bought with a certain moisture content, known as regain. A list of regains for different fibres is given in section III of Chapter III.

COUNTS OF YARN IN CLOTH.—It is frequently considered to be unnecessary to specify the counts of yarn in a cloth where the reed and pick and weight are given, but it will be realised that a wrongly constructed cloth may be supplied, conforming to the latter requirements, but made from a fine warp and coarse weft or vice versa.

In all loom-state cloths, and particularly in those cloths in which no strength is specified, the counts of the yarn to be used should be given together with the tolerance in count variation which will be permitted. Here again the method of testing the counts should be given. The methods of testing for counts are as follows :—

In the case of cotton fabrics, the sample to be tested is thoroughly washed in water in order to remove all size. After washing and drying, the sample should be exposed in an atmosphere of normal average humidity, in order that it will take up its normal amount of moisture.

A length of 120 yards of warp and 240 yards of weft, measured at what is judged to be a weaving tension, should be taken from the cloth and weighed, and the counts calculated from the results obtained, an allowance of 2 per cent. being made for loss in weight of the yarn, both warp and weft, due to washing.

A tolerance of 2½ per cent. above or below the specified counts would probably be found to be acceptable to manufacturers of both cotton and woollen cloths, but in the case of flax, hemp, and jute, a greater tolerance, say of 5 per cent, would probably have to be allowed.

SIZING, LOADING, AND FINISHING MATERIALS.—It will frequently be found necessary to specify that certain substances must not be used in sizing or finishing and it may even be necessary to specify the substance which are to be used. This will often happen when the fabrics have to be proofed or treated in some way, since the presence of certain substances may affect the proofing.

ENDS AND PICKS PER INCH :—The threads per inch in both warp and weft directions should be specified, it being made clear that the threads per inch mean the threads in one inch of the cloth, and not the number of threads which can be seen under a one inch glass.

WIDTH :—In specifying the width, a tolerance above or below the stated width should be permitted so long as the average width is equal to that called for. This last qualification is necessary, since there are some known instances in which a variation of 3/8 inch was permitted on the width specified, and the manufacturer actually made his cloth 1/4 of an inch narrow. The variation

to be allowed will vary for different materials and different qualities, but 3/8 inch should be sufficient for all cotton materials and 1/4 inch sufficient for loom-state worsteds, linens and silks.

WEIGHT :—In fabrics in which the counts are specified it is not necessary to specify a weight, but in all other cloths a pure weight should be specified, and in this connection a tolerance of $2\frac{1}{2}$ to 3 per cent. below the specified weight be permitted.

STRENGTH :—In all finished and in many loom-state cloths a strength should be specified, not because the strength itself is always an important factor, but when it is not important the strength will generally indicate the quality of a material, its resistance to wearing, and, in the case of a finished cloth, shows whether it has been weakened in the finishing processes.

It is highly probable that more diffierences and disputes arise between suppliers and consumers on the question of strength testing than on all the other tests and inspections which are made on textile materials. The reasons for this are two-fold :— (1) One or other party does not realise the very great variation which will be found from piece to piece, and even in different specimens taken from the same piece of the most regularly spun and woven material. As a result of this one frequently finds that the strength figures given in specificaions are the actual average results obtained from the testing of one or two samples. The issue of such specifications is bound to result in endless disputes. (2) The other reason is due to no account being taken in the specification of the varions factors which influence very

considerably the strength of textile fabrics. The first of these factors is the amount of moisture in the· specimen at the time the test is made. In linen, cotton, and hemp materials the greater the moisture content ·the higher will be the strength, but in silk and woollen materials the greater the moisture content the lower will be the strength. There are three methods which may be employed to ensure that when tests are made he materials shall have a ˙constant moisture content. These are :— (a) After the test specimens are prepared to the requisite size they are soaked in water for two hours, after which they are taken from the water, the excess of adherent water removed, and tested immediately. This is the most simple method of ensuring a constant moisture content in a material for strength testing. The tests are easily made, and no elaborate or costly plant is required. It will be realised, however, that for certain proofed and finished fabrics in which certain substances have been used this method of testing cannot be employed.

(*b*) Another method which is sometimes adopted is to dry the prepared test specimens at a temperature of 275 deg. F. for $2\frac{1}{2}$ hours. The specimens are then placed in a dessicator and allowed to cool. After cooling they are taken rapidly from the dessicator one by one and tested immediately. The object of this method is to test the specimen in an absolutely dry condition, but it will be found that the specimen does take up a certain amount of moisture from the time it is taken from the dessicator and fixed in the jaws of the testing machine. It is not so simple a method as the wet method, but is a most useful test to apply to fabrics which . have to

be treated with rubber and then vulcanised, since the temperature at which the specimens are dried is the temperature of vulcanisation. With this method as with the former certain proofed and finished materials cannot be tested, since the physical properties of certain of the substances employed will be considerably changed at a temperature much lower than 275 deg. F. (*c*) The third method is one which is suitable for all materials whether in the loom—state, finished, or proofed. It is to keep the atmosphere of the room in which the samples are exposed previous to testing and in which the testing is carried out in a constant condition of humidity. The relative humidity should be that at which the various textile materials in the grey state will contain their normal amount of moisture, and should be round about 70%. When the relative humidity falls below 70% some means should be employed to mix water vapour with the air, and when it goes above 70% to dry the air. Proofed and finished fabrics will not necessarily contain their normal amount of moisture at this degree of humidity, since this will depend on the deliquescent nature of the substances employed in finishing and proofing, but the tests will be strictly comparable when the same substances have been used in finishing and proofing. This is the method employed at the Manchester Chamber of Commerce testing house, and since its adoption there at a number of American testing houses.

TYPE OF TESTING MACHINE—The next factor which influences considerably the strength of a fabric is the type of machine on which the tests are made. There are two types of machines employed for this purpose

(*a*) machines in which the travelling jaw is pulled out at a constant speed, and (*b*) machines in which the load is applied to the fabric at a constant rate. Now the rate at which a specimen is loaded considerably influences its breaking load. When a high rate of loading is employed the breaking load will be found to be greater than when a low rate is employed. The most satisfactory constant rate of loading machine employed for fabric testing has to be kept in equilibrium by the operator turning a hand-wheel, and the accuracy of the testing depends to a great extent on his skill and carefulness. Anyone who has actually made large numbers of tests on such machine will agree that exceptionally great care must be excercised in order to obtain satisfactory tests. For investigation work in which it is desirable to compare materials of greatly different strengths, structures, weights, and elasticities, this is the only type of machine on which truly comparable results will be obtained.

For contractual testing, however, in which material is tested against specification figures and where the results obtained are to be comparable only with those obtained on similar materials, the use of machines of which the moving jaws have a constant rate of traverse, is recommended. The rate of traverse of the travelling jaw should be specified, and is generally 18 inches per minute. The use of this type of machine is advocated because very little is left to the skill of the tester except the fixing of the specimen in the jaws. If a constant rate of loading machine were made in which the extension of the test specimen could be taken up by some means other than a hand-wheel it would certainly be

much superior to either of the machines which have been mentioned.

SIZE OF TEST SPECIMENS—In specifying a strength for a fabric the size of the test specimen to be used should be specified, and a very useful purpose would be served by some authority if they would or could standardise this size. To-day fabrics are tested on all sizes of test specimens from 1 inch wide × 30 inches long to 6-⅝ inch wide × 7 inches long. Sometimes the length which is given is not the length between the jaws but the overall length, which includes the portion of the fabric which is clamped in the jaws. So long as the length between the jaws is given it is not necessary to specify the overall length, providing sufficient material is left at each end to permit of the sample being fixed fairly and securely in the jaws. An investigation was carried out at the National Physical Laboratory (Teddington) in order to investigate the effect on the breaking load of different dimensions of test specimens. It was found as a result of this investigation that (1) the strength of a specimen decreases as its length increases and as its width increases; (2) the decrease of strength is no longer operative after the specimen has reached the dimensions of about 2 inches wide by 7 inches long. It is therefore recommended that all cloths be tested on specimens 2 inches wide by 7 inches between the jaws, and that the specimens be cut 2½ inch and frayed down on either side to the desired width. Six warp and six weft specimens, no two containing the same longitudinal thread, should be tested from each sample, when it will be found that a fair average strength of the material will be obtained. In specifying the strength it should be

given as lb. per inches width, whatever the width of specimen employed.

SHRINKAGE.—It is desirable that certain cloths should shrink as little as possible when washed, as in the case of material which is to be made into garments. With such cloths it is usual to specify that they shall not shrink more than a certain percentage in warp and weft directions when washed in hot water and soap and allowed to dry.

A minimum shrinkage is also desirable in canvas and duck to be used for test construction or in certain fabrics it should be specified that they should not shrink more than a certain percentage when left in running water for four hours and then allowed to dry.

FASTNESS OF DYE.—The following tests should be made as to fastness of dye, and the material supplied should not be inferior to the standard when subjected to (*a*) boiling in a hot water, (*b*) boiling in a soap solution, (*c*) boiling in a soda solution, and (*d*) washing by hand in hot water and soap. It will some time be found necessary in some cloths to compare the fastness of the dye with action of light when compared with a standard sample.

WATER TIGHTNESS :—All waterproofed fabrics must be tested as to their waterproof properties. For proofed Gaberdine and similarly proofed materials the method usually employed is that known as the spray method. In this method a square foot of the material is stretched and fixed on to a board, which is supported at an angle of 45 deg. Between the fabrics and the board is placed a sheet of blotting paper. A continuous spray of distilled water is then allowed to drop on the fabric across its

width at the top of the frame from a height of about 6 in. After six hours the blotting paper between the fabric and the board should not be wetted.

For rubber, oilskin, and similarly proofed materials a disc of the fabric about 6″ in diameter is clamped on the large end of a funnel-shaped instrument. The fabric is· then subjected to a certain water pressure according to its weight and quality, when no leakage should take place. .

Proofed fabrics which are to be used for tents are tested in a different manner, since the former is not sufficiently severe and the latter too severe. A ten inch square piece of fabric should be folded like a filter paper, placed in a glass funnel, and loaded with 300 cc. of distilled water. After 24· hours no water should leak through the fabric and the under side should be dry.

ROPES AND CORDAGE :—In addition to the materials which have already been mentioned, the Textile Inspector has also to carry out the inspection of ropes and cordage. Cordage is made from $\frac{1}{8}$ lb. up to 2 lb., and the weight is the weight in lb. of a hank of 60 yards. Ropes are usually designated by their size, thus a $\frac{1}{2}$ inch rope has a circumference of $\frac{1}{2}$ inch, and a 2 inch rope a circumference of 2 inches. In rope and cordage specification the following should be specified :—

> (a) The quality of fibre.
> (b) The number of strands in the rope.
> (c) The cost of single yarn used in the strands.
> (d) The angle of lay or angle of twist.
> (e) The extension under certain loads and the breaking load.
> (f) Length in a fixed weight or vice-versa.

29

In connection with the count of the yarn, different systems are used in different localities. In some the lea count is used, in others the dry spun flax or jute system, *i.e.*, weight of the yarn in lb. per spindle ; while some rope manufacturers use quite a different system, the count of the yarn being expressed by the number of yarns of that particular count which would be required to make one of the three strands of 3-inch rope.

In carrying out strength tests on ropes, the specimens should not be less than 6 feet. between the jaws, since with shorter length very unsatisfactory and variable breaks result. Many methods of gripping the ends of the jaws have been experimented with, including the moulding on both ends of the test specimens of resin wedges, but it is found that the best method is to use long taper grips about 12 inches long, and to wrap the rope with tarred string.

VISUAL EXAMINATION OF TEXTILE MATERIALS:—All textile material should be carefully examined for manufacturing or finishing defects. In the case of yarns, cordage and ropes, one bundle or coil should be examined from each 20 to 25.

In the case of cloth in the piece form, it will be frequently found necessary to examine every piece, and with certain materials a considerable saving of time might be effected by the cloth lookers being instructed to mark defects in the cloth which have to be cut out before making up. With certain materials it is not necessary to examine or test every piece, but the number of pieces to be looked at or tested will depend upon the knowledge of the supplier's products.

SECTION II

Out lines of some specifications

Specification No. 1 for Cotton Twine 5/10*.

MATERIAL :—The yarn composing the twine should be. manufactured from good, clean, long stapled cotton, and be evenly spun.

The twine must conform to the sealed sample, be well twisted, free from flaws, too many knots and other faults. It must be neatly and tightly wound in well formed balls and free from size or dressing.

MANUFACTURE :—The twine should conform to the following particulars ;—

Count of single thread composing the twine.	No. of single threads forming the twine.	Breaking load of single thread (Length of test piece 12″)	Twist per 3 inches of twine.	Breaking load of a lea (120 yds) of twine	Weight of a lea (120 yds.) of twine.		How delivered.
					Grains.	Ozs.	
10^s	5	16 Ozs.	36	600 lbs	568	1·3	In balls weighing approximately 2 Ozs.

Note:—(Temperature 72°F, relative humidity 15% for single thread) Temperature 71°F, relative humidity 47% for made up twine).

Specification No. 2 for Lining cloths, Cotton Satin

MATERIAL :—The cloth shall be woven from yarn evenly spun from clean cotton. It shall be free from weaving faults and the selvedges well fromed.
The design, weave, shade and finish shall be in accordance with the sealed sample.

DYE :—The dyed cloth shall be of uniform shade. The linings shall not stain in wear and shall resist the action of perspiration.

SUPPLIES :—Supplies shall conform to the manufacturing particulars given in the schedule for the particular quality ordered.

DETERMINATION of weight per square yard for $8\frac{1}{2}\%$ regain. Test samples, each one foot square and no less than three in number shall be cut to represent a fair average of the fabric under test. These samples shall be dried in a conditioning oven to constant 'bone dry' weight at $220°F/230°F$ and an addition of $8\frac{1}{2}\%$ to the bone dry weight shall be the weight for constant regain.

METHOD of cutting test strips for determination of tensile strength. Each strip shall be cut, either warp or weft way, about 11″ long and 7″ wide and the width then reduced to 6–5/8″ by fraying out an approximately, equal number of threads from both sides of each strip.

An average on a minimum of five tests each way shall be taken.

SCHEDULE TO SPECIFICATION NO. 2.

for

Lining cloths, Cotton Satin

No. of quality	Nomenclature	Minimum ends per inch	Minimum picks per inch	Width	Minimum weight per sq. yd for 8½% regain in ozs.	Tensile strength on 6-5/8" x 6-5/8" test strips			
						In air dry condition at a relative humidity of 65%		After 4 hours saturation in water	
						Warp	Weft	Warp	Weft
1	Italian lining black grey or khaki	72	108	54"	4-1/4	120	200	110	180
2	do do	70	94	53"	3-1/4	170	160	200	195
3	Striped sleeve lining	72	108	39"	3-1/4"	155	160	150	180
4	do do	102	56	39"	3-1/4	290	80	250	70
5	Silicia cloth	72	96	54"	3-1/4	140	150	130	135

Specification No 3, for Muslin, Bleached.

MATERIAL:—The cloth is to be made of yarn evenly spun and made from a good cotton of the same quality as the sealed pattern. It must be well woven and free from stains, specks, and weaving and bleaching defects. The selvedges must be well formed.

MANUFACTURE:—The cloth should conform to the following particulars:—

(1) Width of cloth = 36″
(2) Length = In pieces of approximately 40 yards.
(3) Weight per lineal yard. = 1·3 ozs.
(4) No. of threads per inch warp way. = 56
(5) No. of threads per inch weft way. = 42
(6) Weave   plain
(7) Minimum breaking strees in lbs. size of test piece 6 5/8″ × 6 5/8″ between grips,   } Warp 100 Weft 55

Note:—The figures for breaking strengths are meant for a normal humid atmosphere and are to be determined from an average of six tests each way: a variation of 7% either way being allowable for individual tests.

GENERAL:—(i) The cloth should be thoroughly bleached and free from stains, specks, etc. All traces of chemicals used in bleaching must be removed from cloth.

(ii) The cloth must be absolutely free from size or dressing of any kind.

DEVIATION: The weight of a piece is to be considered
ALLOWED:— as an average weight, an up and down varia-
of 5% being allowed for individual pieces
ordinarily. During the monsoon months an
overweight up to 8% may be allowed.

Specification No. 4 for Sheets, ground, waterproof, Cotton Canvas

MATERIAL :—The cloth should be made of cotton, not
inferior to the sealed pattern of the following
particulars :—

Warp threads per inch—44 (fourfold yarn)
Weft   ,,   ,, ,, . — 32 (threefold yarn)
Weight per sq. yard 17 ozs.
Minimum breaking strain Warp 500 lbs.
                        Weft 400 lb.

Size of test strip 3″ × 7″
between grips.

Manufacture :—The sheet is to be made of
one piece i.e. without joints whatever.

HEMMING :—The transverse ends of sheets are to be
hemmed to a depth of 5/8″, the raw edge be-
ing turned in so as to coincide with the line on
which the outer edge of the hem will fold.
The stitching may be either hand or machine
sewn. If hand sewn the stitches are not
to be less than 4 to the inch. If machine
sewn the stitches should be not less than 5
inch ; the stitching must be in any case secu-
rely fastened off by hand sewing. For hand

sewing "thread, flax, undyed "4 ply, well' waxed is to be used and for machine sewing " thread, linen, machine universal. No. 10 three cord" should be used. The sewing thread must be immersed in castor oil before use. The stitches must not run if an end is pulled.

False hemming is prohibited. There is to be no hemming lengthwise as the long sides have selvedge ends.

EYELETS :—There should be a brass eyelet at each corner of the sheet and one fixed half way down· the length at each side. No. 21 eyelets are to be used. The cornor eyelets are to be inserted at the hemming. The holes for eyelets must be made by separating the warp and weft with a marline spike. The holes may be made by first punching a hole not over half the diameter of eyelet shank and than enlarging this hole with a marline spike to take the eyelet. All the eyelets on each side are to be fixed in one straight line. The eyelets are to be well and truly set in the material and must not be loose split or deformed.

SIZE :—The sheet should be of following dimensions :—
7'—O" × 3'—8" (finished dimensions).

TEST FOR WATER LIGHTNESS :—The sheets shall be well folded and the surfaces rubbed together to remove any superficial dressing. They will then be placed, each on a testing frame in the

shade, clear of the ground and so that each gives a reasonable sag for reception of water. Water will then be poured into a depth of 4″, the depth to be as uniform as possible. Should any leakage occur within 10 hours the sheets should be rejected.

Specification No. 5 for Serges, blue, worsted

MATERIAL:—(a) The cloth shall be manufactured from good, sound, worsted yarn evenly spun from wool equal in quality to that used in the sealed sample. The yarn shall be free from any admixture of cotton, or other spurious, recovered, or shoddy materials.

(b) Supplies shall conform strictly to the sealed sample in finish, thickness and shade, and shall be uniform and free from streaks, stains or other defects. The dye shall be fast to exposure to light, air, petrol washing, friction, steaming and ironing, and perspiration.

MANUFACTURE:—The particulars given below represent the minimum acceptable in any supplies offered :—

(1) Ends per inch   ... 762 fold worsted twisted.
(2) Picks per inch   ... 722 fold worsted twisted.
(3) Width   ... 56″
(4) Weight per square
    yard for a regain
    of 16%   ... 11·8 ozs.

(5) Tensile strength in
air dry condition
at a relative hu-
midity of 46% on
6 5/8″ × 6 5/8″
test strips ... Warp 450 ℔. Weft 365 ℔.

SHRINKAGE:—Deliveries shall not shrink more than 2
per cent. either in the warp or in
the weft. Samples tested shall be
soaked for two hours in cold water,
lightly wrung by hand, and allow-
ed to dry on a flat surface at a tem-
perature between 60°F and 70°F.

Method of cutting test strips for determination of tensile strength. Each strip shall be cut, either warp or weft way, about 11″ by 7″ wide and the width then reduc-ed to 6 5/8″ by fraying out an, approximately, equal num-ber of threads from both sides of each strip.

An average on a minimum of five tests each way shall be taken.

Determination of weight per square yard for 16% *regain.* Test samples, each one foot square and no less than three in number shall be cut to represent a fair aver-age of the fabric under test. These samples shall be dried in a conditioning oven to constant 'bone dry' weight at 220°F/ 230°F and an addition of 16% to the bone dry weight shall be the weight for constant regain.

Specification No. 6 for Broad cloth woollen

MATERIAL:—The cloth shall be woven from good and sound woollen yarn and shall be free from any admixture

of cotton or other spurious, recovered or shoddy materials. The selvedges shall be well made.

DYE:—Supply shall conform to the sealed sample in shade which shall be uniform throughout. It shall be free from streaks, stains and other defects. The dye shall be fast to exposure to light, air, petrol washing, friction, steaming and ironing and shall withstand the action of acetic acid.

MANUFACTURE:—The manufacturing particulars shall conform to the schedule attached to this specification.

FINISH:—Supply shall be fulled, napped and sheared down close and shall have a smooth and lustrous appearance, obtained by wetting, steaming, calendering and hot pressing.

The cloth shall be delivered quite dry and without any smell of grease or soap.

SCHEDULE TO SPECIFICATION No. 6.

Quality Number	Weave.	Ends per inch woollen, minimum.	Picks per inch woollen, Minimum.	Width.	Weight per square yard for a 16 p.c. regain.	Minimum tensile strength for 6-5/8″ x 6-5/8″ test pieces in air dry condition at a relative humidity of 75 p. c.		Remarks.
						Warp	Weft	
1	Twill	28	22	56″	16 ozs.	260	200	Medium.
2	Twill	54	52	56″	10·75 ozs.			Heavy
3	Plain	38	34	54″	8 ozs.	110	120	Fine.

SPECIFICATION No. 7

for

CLOTH, GUNNY, JUTE

MATERIAL :—The gunny cloth shall be manufactured from a good quality of Jute and have a texture, finish and general appearance not inferior to the sealed sample.

MANUFACTURE :—The particulars given below represent the minimum acceptable in any supplies offered :—

Weave	Plain
Structure	11 porter (double ends) 12 shot (single) per inch
Width	22″
Weight per sq. yard for a regain of 13 ¾% ...	19·5 ozs.
Count of warp ...	5^S approx
Count of weft ...	2·75^S approx.
Twist per inch of warp	3
Twist per inch of weft	2

Note—The count of warp and weft given above is on the basis of the number of 300 yard hanks to the pound.

The cloth shall have a red stripe composed of two double ends' running along the length of the fabric.

SPECIFICATION No. 8

for

CANVAS FLAX

MATERIAL :—The canvas shall be manufactured from properly twisted yarn spun wholly from flax and free from blacks. No deleterious substance or weighting material shall be used in the process of manufacture. The canvas shall be uniformly woven and free from weaving flaws and the selvedges shall be well formed.

MANUFACTURE :—The canvas shall comply with the following requirements :—

Minimum No. of threads per inch		Weight per sq. yd. in ozs.	Minimum tensile breaking stress in lbs. (saturated)		Size of test strip
Warp	Weft		Warp	Weft	
27	19	28	450	450	1″ x 7″
double	single				

THE END

Buy

ELGIN FABRICS
&
BE SATISFIED

— ✦ —

Manufacturers of :—

Grey, Bleached and Dyed Yarns, Dhoties, Sheetings, Bleached and Dyed Drills, Twill and Pugri Cloths, Flannelette, Turkish Towels, Dusters, Filter Cloth Bandages, Gauze Cloth, Absorbent Cotton, etc. etc. Durries and Tents a speciality

— ✦ —

THE
ELGIN MILL CO. LTD.

Managing Agents :—

BEGG, SUTHERLAND & Co. Ltd.
P. O. Box No. 11
CAWNPORE

TO ALL WHOM : : : :
: : : IT MAY CONCERN

YOU CANNOT DO BETTER THAN
ENTRUST YOUR ORDERS FOR :—

YARN

CLOTH

CORDAGE

TENTAGE

Made to I. S. D. or Ordnance Specifications ;
with Tests Guaranteed.

𝓖o

Messrs. H. BEVIS & Co.

P. B. No. 29
CAWNPORE (U. P.)

Proprietors of:—

THE NARAYAN COTTON SPINNING AND WEAVING MILLS
THE CURZON TENT FACTORY
THE INDIAN BRUSH FACTORY
CAWNPORE

The Pearl Products Co. Ltd.,

Cawnpore

Manufacturers of—

The Textile & Tanning auxiliaries

(1) All kinds of Turkey Red Oils—Sulphonated Oils

(2) All kinds of Soft Soaps—Potash Soft Soaps.

(3) Wheat & Maize Starches.

(4) White, yellow, Dextrines, British gums,
'Spinoxygel', 'Resonal' Metanole 'Brilliant'
Pearlaxol 'B', 'Glazine' G. K. Sulphokol 'S'
etc,, etc.,—special sizing & finishing materials

Write for a sample and pamphlet to-day.

Other Publications of the Society

DYER'S DIRECTORY 1933	Price		0	8	0
DYER'S ANNUAL 1934	,,	,,	1	8	0
DYER'S ANNUAL 1935	,,	,,	1	8	0
TEXTILE ANNUAL 1936	,,	,,	1	8	0
RESHO KI RANGAI (In Hindi)					
By. D. G. KALE, B.Sc.	,,	,,	5	0	0

DATE OF ISSUE ·

This book must be returned
within 3, 7, 14 days of its issue. A
fine of ONE ANNA per day will
be charged if the book is overdue.

PHARMACEUTICS

Analysis and Testing of
Textiles